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The Marine Fauna of New Zealand: Ostracods of the Otago Shelf

by

K.M. SWANSON

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The Marine Fauna of New Zealand: Ostracods of the Otago Shelf

by

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New Zealand Geological Survey, Christchurch*

ABSTRACT

In a total of 163 sediment samples from the continental shelf off Otago (east coast, South Island, New Zealand), 63 ostracod species have been recognised. Nineteen species are described as new. One new genus *Jacobella* and one new subgenus *Pseudocythere* (*Plenocythere*) are proposed. Characteristic species and sediment parameters of the five ostracod assemblages are listed. Studies of the distribution patterns of individual species indicate that the influence of substrate (sediments) on ostracod distribution is not as obvious as suggested by previous work. Many species display a wide tolerance of variations in sediment texture, grain size, and sorting. Both the Southland Current and a post-glacial rise in sea level appear to have been responsible for the anomalous distribution of the relict population.

INTRODUCTION

In 1967 the Portobello Marine Biological Station of the University of Otago, New Zealand, under the Directorship of Dr Elizabeth Batham, began a sampling programme on the continental shelf area adjoining the Otago Peninsula (Fig. 1). Some 163 bottom samples were then made available to the author for the study of the Recent ostracod fauna. The study was carried out principally while the writer was a member of the Sedimentology Section of the New Zealand Geological Survey, Christchurch, between 1968 and 1970. The work was continued overseas at the Denver Research Centre of the Marathon Oil Company during 1971. Early in 1972 some three months were spent at the British Museum of Natural History on comparative work using the large ostracod collections there. Dr Peter Andrews carried out the sedimentological research of all samples used in this study.

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BATHYMETRY

The area studied is located on the south-east coast of South Island, New Zealand (Fig. 1, inset) between longitude 170°35' and 170°5'E and latitude 45°37' and 45°59'S, covering approximately 736 km² (460 square miles) of sea floor.

The sea floor in the area is mainly continental shelf sloping gently south-eastwards, occasionally interrupted by drowned wave-cut cliffs and terraces. A large spit partly separates Blueskin Bay, the shallow coastal embayment north of the Otago Peninsula, from the open shelf (Fig. 1). Each distinct break in the continental shelf slope, which takes the form either of a sharp step or a marked but smooth change-in-slope, appears to mark the position of a shoreline formed during a Pleistocene low

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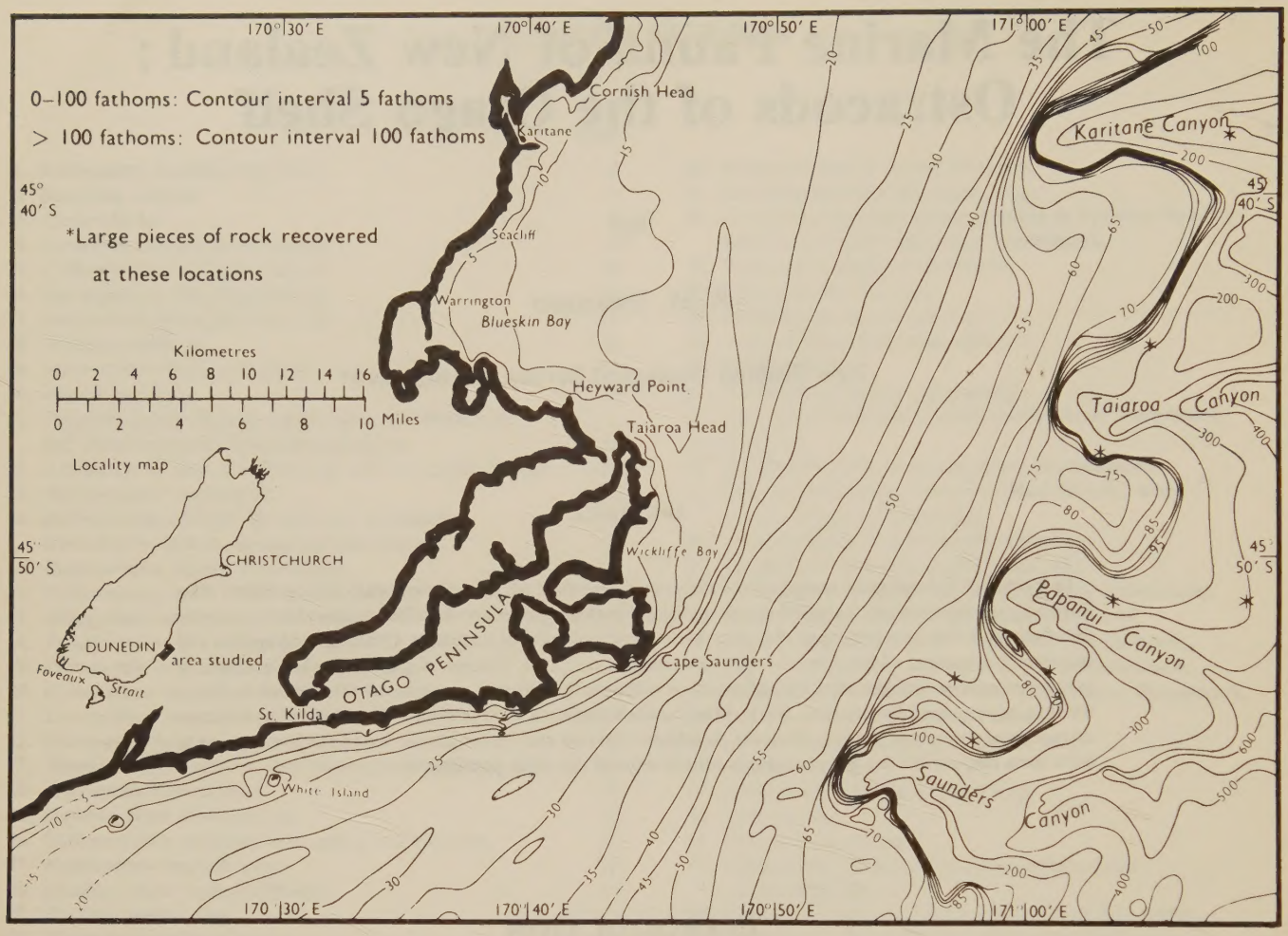


FIG. 1. Bathymetry: soundings in fathoms (1 fathom = 6 feet = 1.83 metres). Locality map inset.

stand of sea level. Two such shorelines occur at depths of 56–68 m (30–36 fm) and 88–104 m (48–56 fm). A third, less well defined shoreline occurs at 113–132 m (61–66 fm). The edge of the continental shelf is situated between 120–155 m (65–85 fm) throughout the area.

Gross bathymetry shows the canyons to be crudely V-shaped valleys combining eastwards to merge with the Bounty Trough.

COASTAL CURRENTS

Coastal water circulation in the area is dominated by the Southland Current (Brodie 1960). This confined surface current, flowing north-east along the Southland and Otago coast, consists of subantarctic water mixed with Tasman Sea subtropical water that has deflected south-east through Foveaux Strait and around Stewart Island (Burling 1961; Houtman 1966). East of Otago Peninsula the Southland Current flows over most of the outer half of the continental shelf and over the upper continental slope (Jillett 1969). In the study area, Southland Current water occupies the complete water column over the shelf. The core of the current is centred over the 100 m (325 ft) isobath, moving slightly inshore during summer and slightly offshore during winter. During mid-summer the core lies at depths of approximately 38 m (125 ft). It is possible that the core coincides with the zone of maximum current velocity throughout the year.

COLLECTION AND SAMPLE TREATMENT

All samples were collected with a modified Agassiz trawl, the sampling stations being shown on Fig. 2. The 1.5 litre sample obtained on each occasion represents a trawl track no more than 90 m (100 yd) long, and commonly much less. Collections extended over a period of about three years, and so seasonal fluctuations and migrations in the ostracod populations could not be taken into account.

The majority of the samples, on arrival at the Sedimentation Laboratory, N.Z. Geological Survey, still

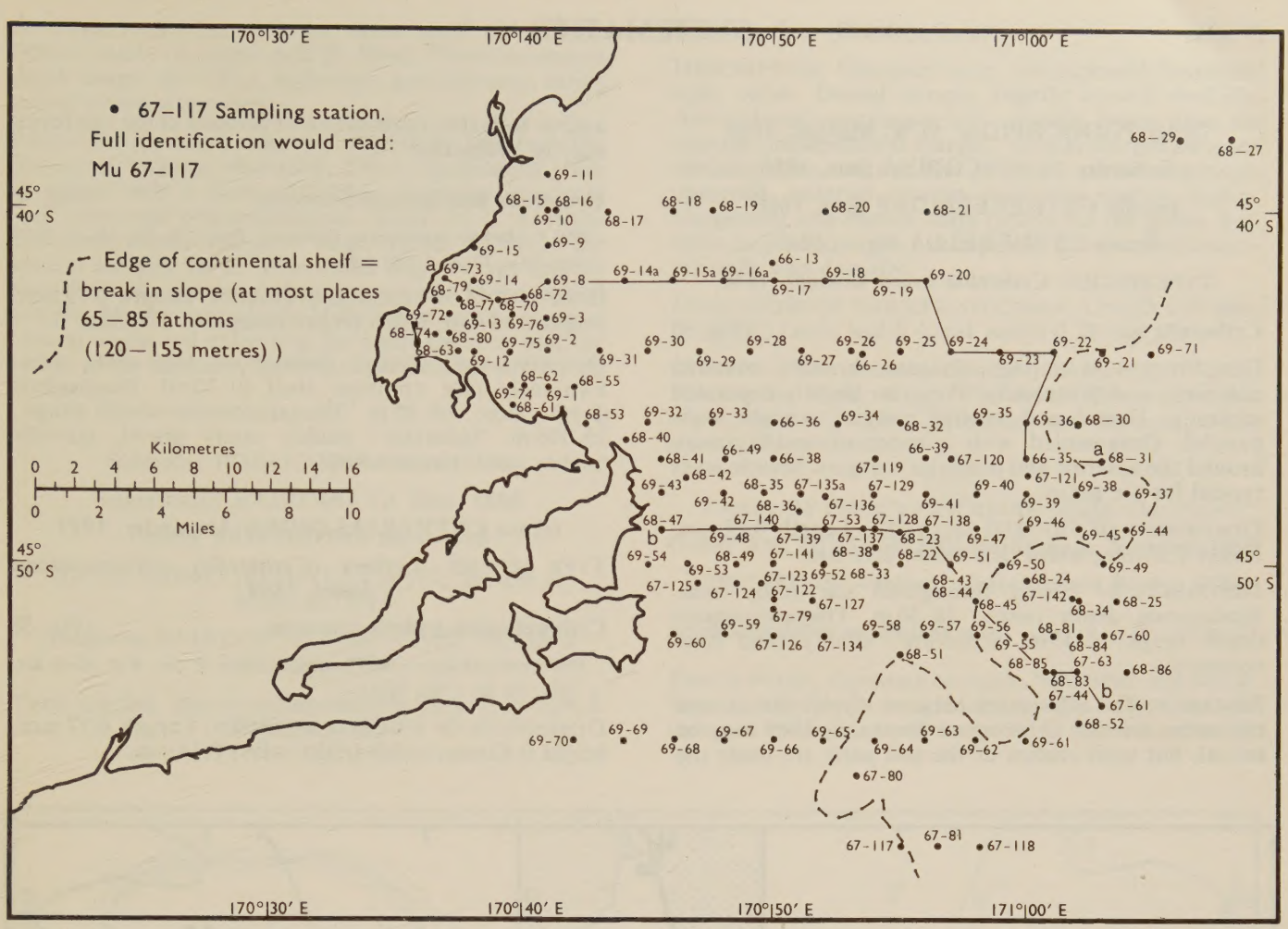


FIG. 2. Sampling stations. Lines a–a and b–b are sample traverses for Fig. 58 (i, ii).

retained considerable amounts of water. Samples were immediately split and washed through a 4.0 ϕ (very fine sand) sieve and scanned wet. During the initial scan the presence or absence of live ostracods was noted. Some specimens were seen to be moving even after washing with fresh water, although most were dead. Dead specimens were opened completely and the soft parts examined to ensure that they were not the chitinous remains of long-dead animals.

Samples were then dried and a fraction of 45–60 g split off for grain size analysis. The sample was treated with 30% hydrogen peroxide to remove carbonaceous material and grain size analyses were made using the techniques described by Folk (1965). For the 1–4 ϕ fraction (medium – very fine sand), samples were sieved at 0.25 ϕ intervals; for the remainder of the sample finer than 4.0 ϕ the analysis was continued using the pipette method.

After grain size analysis all fractions above 1.50 ϕ were picked for ostracods. All specimens picked were mounted on a 60-section micropaleontological slide using gum tragacanth as an adhesive. Abundance counts were made of all species, articulated carapaces and single valves of juveniles and adults being treated separately. The ostracods were drawn by the author with the aid of a camera lucida mounted on a monocular microscope.

All type and figured specimens are registered and lodged in the microfossil collection of the N.Z. Geological Survey, Lower Hutt.

SYSTEMATICS

Order PODOCOPIDA G.W. Mueller, 1894

Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Sars, 1866

Genus CYTHERELLA Jones, 1849

TYPE SPECIES: *Cytherina ovata* Roemer, 1840

Cytherella sp. (Fig. 3)

DESCRIPTION: Carapace elongate, broadly rounded anteriorly and posteriorly. Posterior slightly depressed ventrally. Dorsal and ventral margins straight, subparallel. Ornamented with a series of small puncta around the anterior and posterior margins. Muscle scars typical for the genus.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.72 mm; height 0.35 mm; width (left valve) 0.15 mm.

DISTRIBUTION: Found throughout the study area. Biocoenosis depth range: 18–36 m. Thanatocoenosis depth range: 0–45 m. Substrate: muddy sand (biocoenosis).

REMARKS: The differences between *Cytherella* sp. and the rather similar *C. elongata* Swanson, 1969 may be sexual, but until studies of the soft parts are made the author feels the combination or division of the two forms may be premature.

Cytherella hemipuncta Swanson (Fig. 4)

1969 *Cytherella hemipuncta* Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)*: 37, pl. 1, figs 4–6.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.73 mm; height 0.43 mm; width (entire carapace) 0.31 mm.

DISTRIBUTION: Occurs throughout the study area. Extremely rare on inner shelf (0–50 m). Biocoenosis depth range: 60–85 m. Thanatocoenosis depth range: 25–105 m. Substrate: muddy sandy gravel, gravelly muddy sand (biocoenosis).

Genus CYTHERELLOIDEA Alexander, 1929

TYPE SPECIES: *Cythere (Cytherella) williamsoniana* Jones, 1849

Cytherelloidea willetti Swanson (Fig. 5)

1969 *Cytherelloidea willetti* Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)*: 37, pl. 1, figs 12–13.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.77 mm; height 0.42 mm; width (right valve) 0.14 mm.

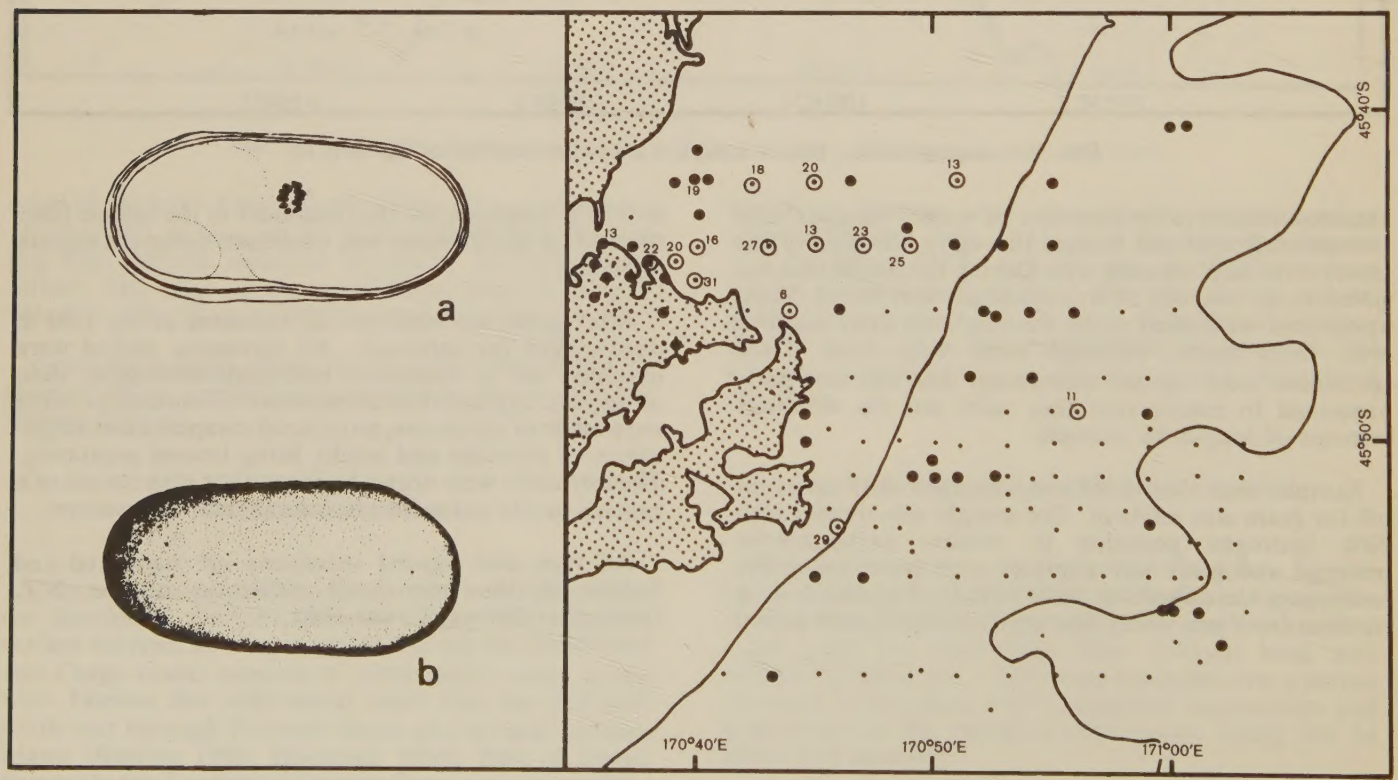


FIG. 3. *Cytherella* sp. (N.Z. Geological Survey Cat. No. OP 1028): a, internal view of female left valve, x 70; b, external view of female left valve, x 70; c, geographic distribution of individual species on the Otago Shelf. Open circles denote samples in which living specimens were found. Closed circles denote that only dead specimens were present. Figures outside the circles indicate the number of live and dead specimens at that station. Stations with less than ten dead specimens only appear without figures.

DISTRIBUTION: Common on outer shelf (50–155 m). Occurs rarely on inner shelf (0–50 m). Thanatocoenosis depth range: 85–120 m. Substrate: gravelly sand, sandy gravel (thanatocoenosis).

REMARKS: *Cytherelloidea keiji* McKenzie, 1967 from the Recent of Victoria, Australia, differs significantly from *C. willetti* only in the positioning of the anteromarginal and transverse posteromarginal ridges. In *C. keiji* the transverse posteromarginal ridge extends almost to the ventral margin. In *C. willetti* this ridge swings sharply away from the posterior, then runs parallel to the ventral margin. On the ventral side of this ridge, at the postero-ventral angle and extending for approximately half the length of the carapace, is a deep depression not present on *C. keiji*.

Suborder PODOCOPINA Sars, 1866

Superfamily BAIRDIACEA Sars, 1868

Family BAIRDIIDAE Sars, 1888

Genus BAIRDOPPILATA Coryell, Sample & Jennings, 1935

Subgenus BAIRDOPPILATA Coryell, Sample & Jennings, 1935

TYPE SPECIES: *Bairdoppilata martyni* Coryell, Sample & Jennings, 1935

Bairdoppilata (Bairdoppilata) sp. (Fig. 6)

DESCRIPTION: Carapace large, subtrapezoid 'bairdioid' right valve. Dorsal margin slightly curved medially. Anterodorsal margin straight, slightly longer than the sinuous posterodorsal margin. Ventral margin incurved medially with anterior and posterior portions strongly upturned, anterior margin extending slightly higher. Hingement and muscle scars typical for the genus. Left valve larger than right, overlap more pronounced antero-ventrally and dorsally.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.97 mm; height 0.51 mm; width (right valve) 0.28 mm.

DISTRIBUTION: Occurs throughout the study area. Biocoenosis depth range: 75–140 m. Thanatocoenosis depth range: 70–170 m. Substrate: gravelly sand, sandy gravel (biocoenosis).

Family BYTHOCYPRIDIDAE Maddocks, 1969

Genus ANCHISTROCHELES Brady & Norman, 1889

TYPE SPECIES: *Anchistrocheles fumata* Brady, 1890

Anchistrocheles arcaforma n.sp. (Fig. 7)

DESCRIPTION: Carapace elongate, 'bairdioid', ark-like in lateral view. Dorsal margin very straight, ventral margin incurved medially. Anterior broadly rounded, strongly

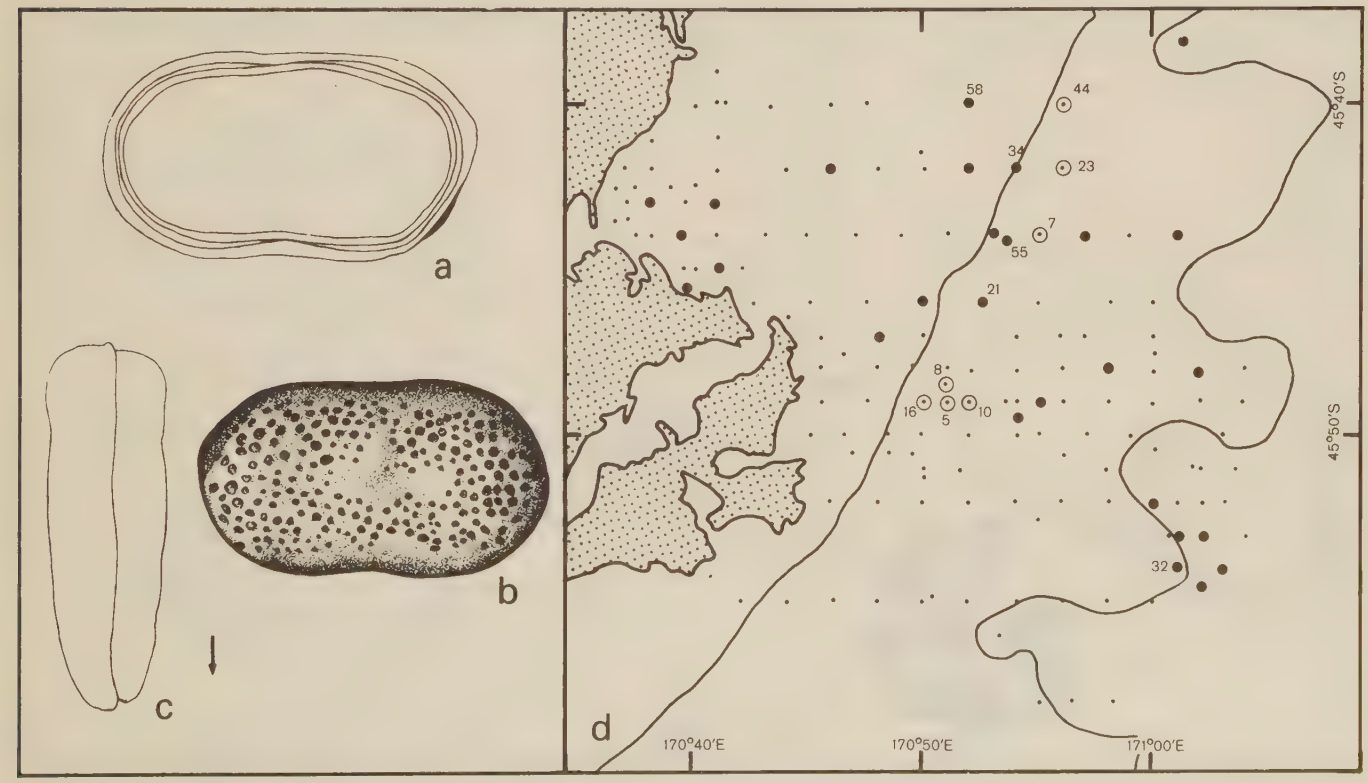


FIG. 4. *Cytherella hemipuncta* Swanson (N.Z. Geological Survey Cat. No. OP 1029): a, internal view of female right valve, x 70; b, external view of female right valve, x 70; c, dorsal view of entire (female?) carapace, x 70; d, geographic distribution.

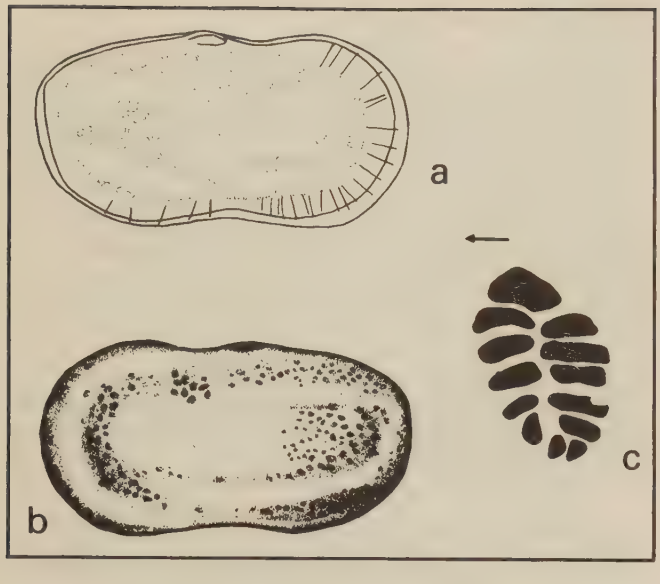


FIG. 5. *Cytherelloidea willetti* Swanson (N.Z. Geological Survey Cat. No. OP 1030): a, internal view of (male ?) left valve, x 70; b, external view of (male ?) left valve, x 70; c, muscle scars, x 200.

upcurved. Posterior strongly upcurved, terminating slightly above mid-point. Terminal margins bearing 8–9 strong spines. Carapace ornamented with a series of small evenly spaced puncta. From dorsal aspect carapace widest slightly posterior of middle, maximum width extending to the anteroventral angle and terminating there as a weakly developed spine. Selvage strong, peripheral throughout. Duplicature widest anteriorly, wide posteroventrally and posteriorly. Vestibule apparently absent anteriorly, extremely narrow posteroventrally. Marginal pore-canals approximately 60 in number, evenly spaced, simple and straight. Muscle scars, a rosette of three sub-circular scars, slightly above which is a larger elongate scar.

TYPES: N.Z. Geological Survey Cat. No. TO 1017. Holotype and one paratype. Mu 68-52, 170 m.

DIMENSIONS OF HOLOTYPE: Length 0.60 mm; height 0.33 mm; width (left valve) 0.11 mm.

DISTRIBUTION: Rare in mid-shelf, outer shelf, and canyon samples.

REMARKS: Easily distinguished from *Anchistrocheles angulata* (Brady, 1870) by the broad, flattened postero- and anteromarginal zones, the curvature of the dorsal margin near the anterodorsal and posterodorsal angles, and the presence of a small node at the posterior end of the dorsal margin of the left valve. Close affinities with Triebel's (1960, pl. 20, Fig. 44(a-b)) figured specimen of *Anchistrocheles* sp. were noted.

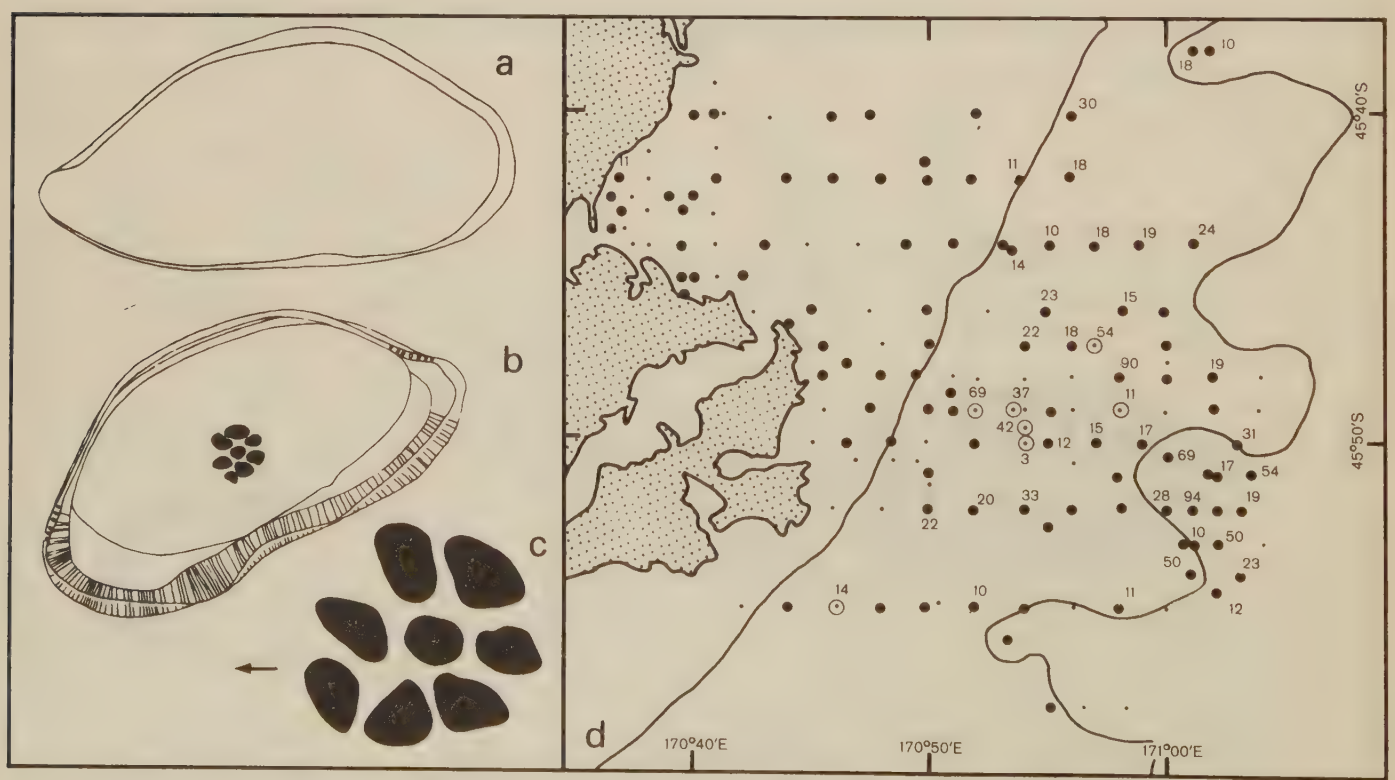


FIG. 6. *Bairdoppilata (Bairdoppilata)* sp. (N.Z. Geological Survey Cat. No. OP 1031): a, external view of right valve showing left valve overlap, x 70; b, internal view of right valve, x 70; c, muscle scars, x 200; d, geographic distribution.

Anchistrocheles sp. (Fig. 8)

DESCRIPTION: Carapace elongate, 'bairdioid'. Dorsal margin straight. Anterior margin upcurved, posterior strongly depressed ventrally. Carapace smooth. Interior: selvage strong, peripheral throughout. Duplicature wide throughout, especially anteriorly. Vestibules well developed anteriorly and ventrally. Line of concrescence slightly sinuous. Marginal pore canals numerous, evenly spaced, straight to slightly curved.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.67 mm; height 0.29 mm; width (right valve) 0.11 mm.

DISTRIBUTION: Rare in mid-shelf, outer shelf, and canyon samples.

REMARKS: Close affinities with *Anchistrocheles fumata* Brady, 1890 were noted. Brady's Samoan specimen (Brit. Mus. Nat. Hist. collection) is, however, very small, measuring only 0.50 mm, whereas specimens from the Otago Shelf averaged 0.70 mm. Both *A. fumata* and *A. acerosa* (Brady, 1868) are more squarely truncated anteriorly than the species described here.

Superfamily CYPRIDACEA Baird, 1845

Family MACROCYPRIDIDAE Mueller, 1912

Genus MACROCYPRIS Brady, 1867

TYPE SPECIES: *Cythere minna* Baird, 1850

Macrocypris (Macrocypris) sp. (Fig. 9)

DESCRIPTION: (Right valve). Carapace large, elongate, and smooth. Dorsal margin strongly arched, ventral margin incurved slightly forward of middle. Anterior broadly rounded, depressed ventrally. Posterior bluntly pointed ventrally. Anterior and posterior vestibules extremely wide. Marginal pore canals short and straight, concentrated anteriorly. Selvage peripheral, widest in the anterior half of the dorsal margin.

DIMENSIONS OF FIGURED SPECIMEN: Length 1.09 mm; height 0.44 mm; width (left valve) 0.21 mm.

DISTRIBUTION: Rare on inner shelf (0–50 m). Common in outermost shelf and canyon samples (100–500 m). Biocoenosis depth range: 82–500 m. Thanatocoenosis depth range: 140–200 m. Substrate: sandy gravel, muddy sand (biocoenosis).

Genus MACROCYPRINA Triebel, 1960

TYPE SPECIES: *Macrocyprina propinqua* Triebel, 1960

Macrocyprina sp. (Fig. 10)

DESCRIPTION: (Right valve). Carapace large, smooth, and tumid. Greatest height medially. Dorsal margin strongly arched; ventral margin sinuous, slightly incurved in the anterior half. Posterior depressed ventrally, sharply pointed. Anterior with broad upward curvature. Duplicature wide anteriorly and posteriorly. Selvage

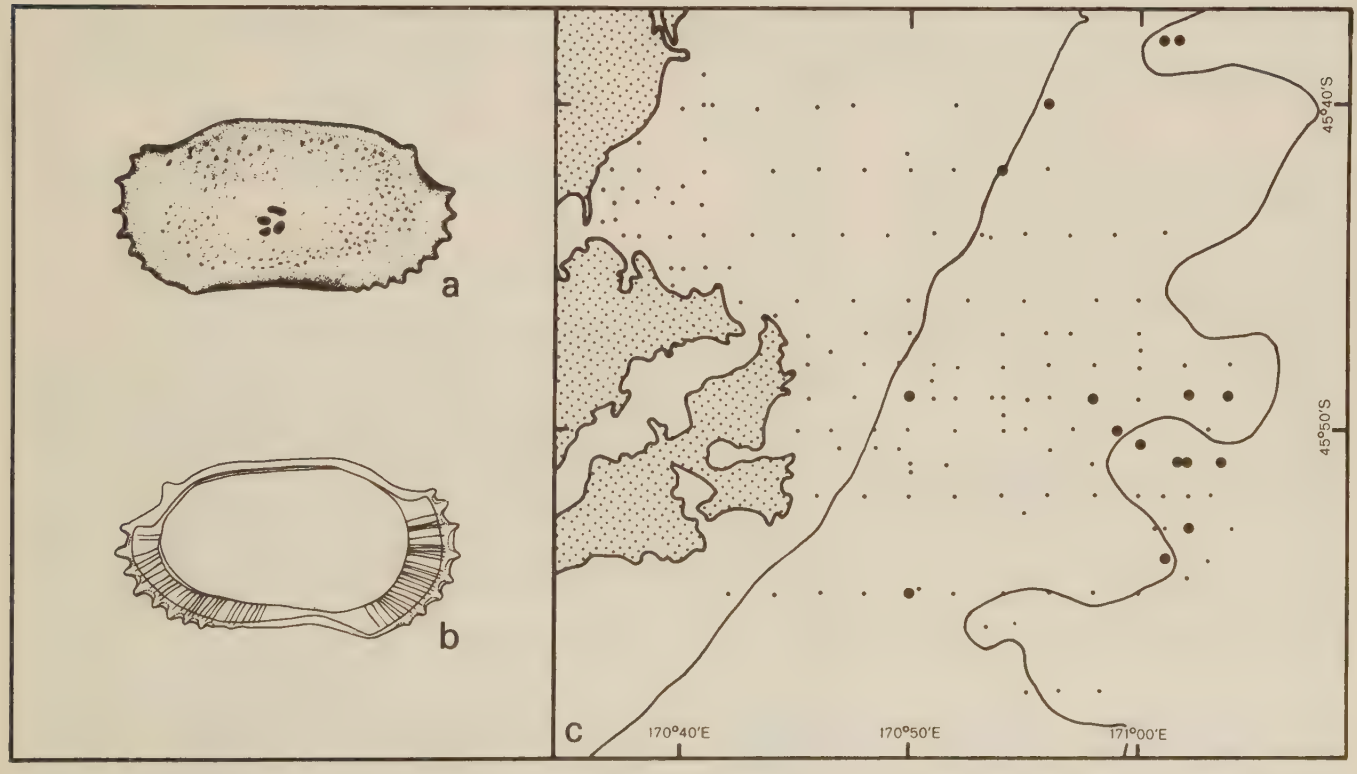


FIG. 7. *Anchistrocheles arcaforma* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1017): a, external view of left valve, x 70; b, internal view of left valve, x 70; c, geographic distribution.

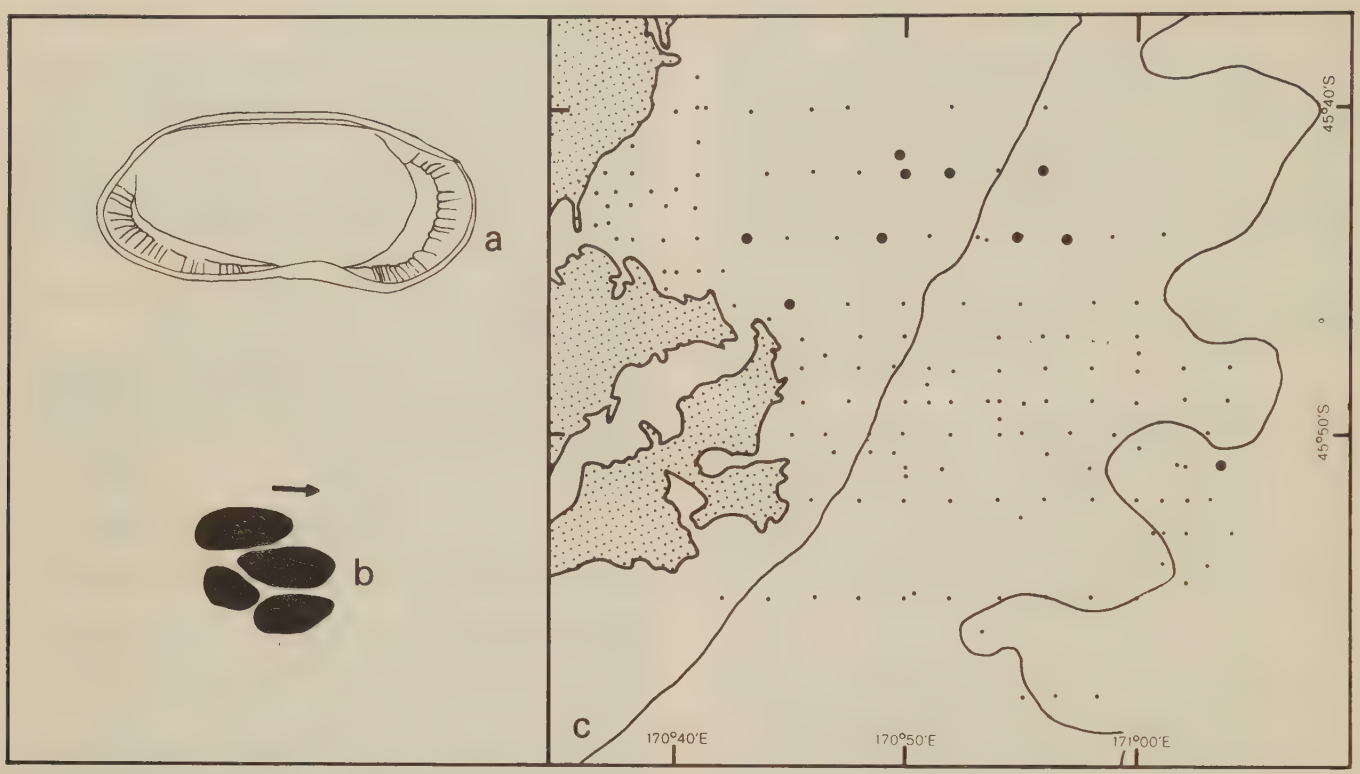


FIG. 8. *Anchistrocheles* sp. (N.Z. Geological Survey Cat. No. OP 1032): a, internal view of left valve, x 70; b, muscle scars, x 200; c, geographic distribution.

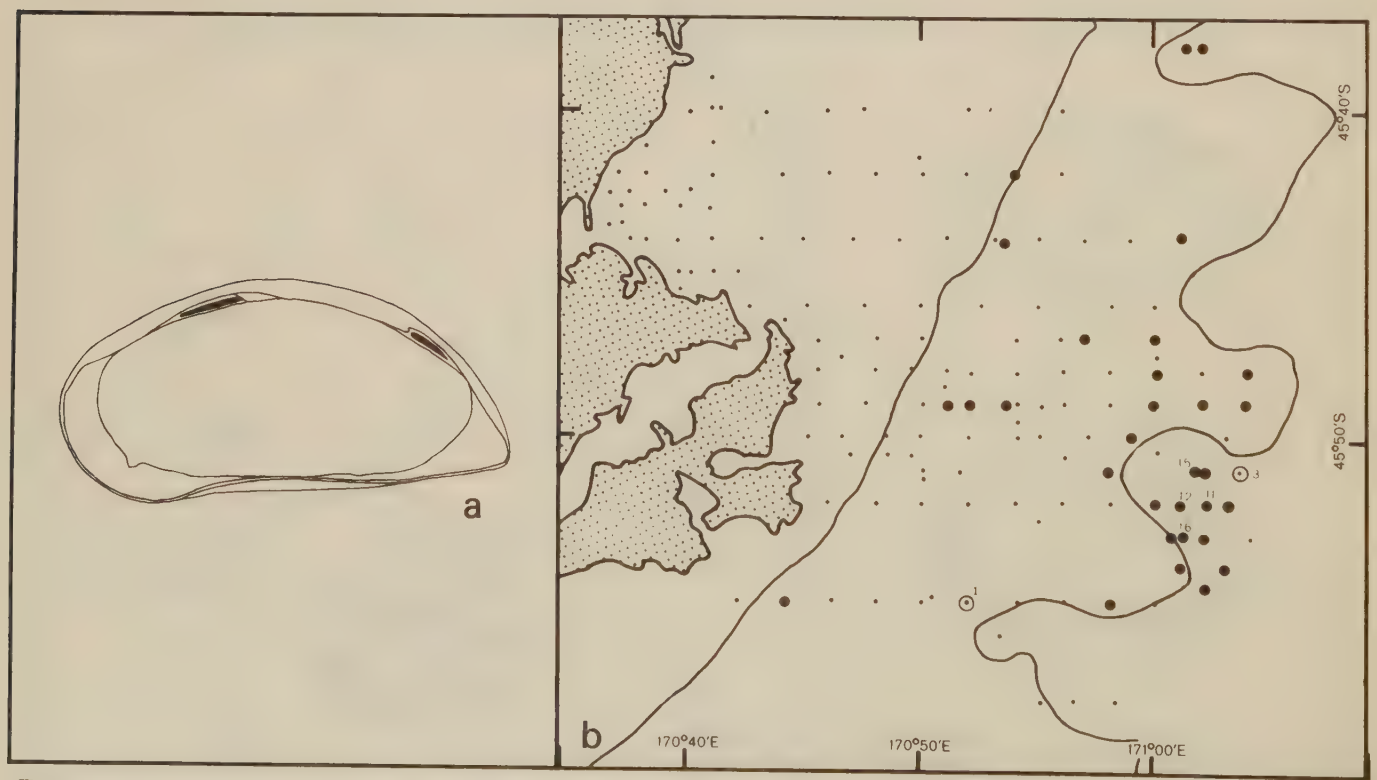


FIG. 9. *Macrocypris (Macrocypris)* sp. (N.Z. Geological Survey Cat. No. OP 1033): a, internal view of right valve, x 60; b, geographic distribution.

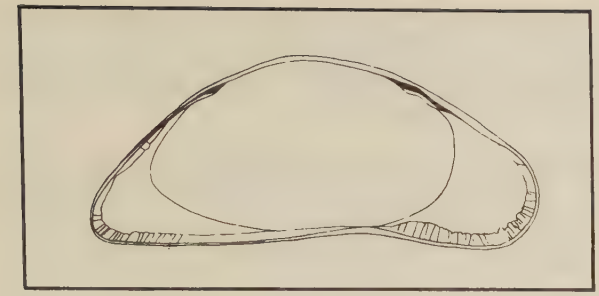


FIG. 10. *Macrocyprina* sp. (N.Z. Geological Survey Cat. No. OP 1034): internal view of left valve, x 60.

narrow anteriorly and ventrally. Hingement consisting of two elongate grooves situated at the anterior and posterior extremities of a median ridge. Detail of this median ridge is obliterated by the strong overlap of the dorsal margin.

DIMENSIONS OF FIGURED SPECIMEN: Length 1.09 mm; height 0.52 mm; width (right valve) 0.34 mm.

DISTRIBUTION: Occurs in canyon samples only. Thanatocoenosis depth range: 170–300 m. Substrate: gravelly muddy sand, sandy mud (thanatocoenosis).

Family PONTOCYPRIDIDAE Mueller, 1894

Genus PROPONTOCYPRIS Sylvester-Bradley, 1947

Subgenus EKPONTOCYPRIS Maddocks, 1969

TYPE SPECIES: *Propontocypris (Ekpontocypris) litoricola* Maddocks, 1969

Propontocypris (Ekpontocypris) epicyrta? Maddocks (Fig. 11a–b)

1967 *Propontocypris* (?) sp., Holden, *Pacific. Sci. 21(1)*: 18, figs 11a–b.
1969 *Propontocypris (Ekpontocypris ?) epicyrta* Maddocks, *Smithson. Contr. Zool. 7*: 33, figs 25–7.

DESCRIPTION: Carapace thin, elongate. Dorsal margin strongly arched, highest slightly forward of mid-point. Ventral margin strongly incurved medially. Anterior margin broadly rounded, depressed ventrally. Selvage peripheral throughout. Duplicature broad anteriorly and posteriorly. Vestibules widest antero- and postero-ventrally. Line of concrescence sinuous. Marginal pore canals numerous, long and slightly irregular, concentrated anteriorly. Muscle scars: a rosette of five scars, composed of two vertical rows of wedge-shaped and rectangular scars.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.67 mm; height 0.36 mm; width (left valve) 0.12 mm.

DISTRIBUTION: Maddocks (1969, fig. 27h, j, k) included several specimens from George Sound, Fiordland, in her report. In the study area: rare in outer shelf and canyon samples.

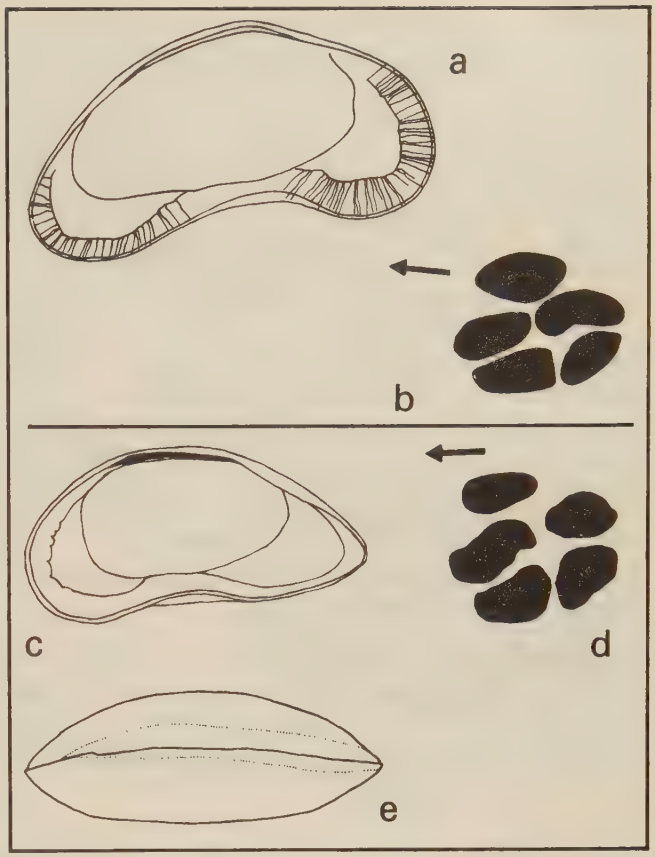


FIG. 11. *Propontocypris (Ekpontocypris) epicyrta*? Maddocks (N.Z. Geological Survey Cat. No. OP 1040): a, internal view of left valve, x 60; b, muscle scars, x 200.
Propontocypris (Propontocypris) sp. (N.Z. Geological Survey Cat. No. OP 1039): c, internal view of right valve, x 60; d, muscle scars, x 200; e, dorsal view of entire carapace, x 60.

Subgenus PROPONTOCYPRIS Sylvester-Bradley, 1947

TYPE SPECIES: *Pontocypris trigonella* Sars, 1866

Propontocypris (Propontocypris) sp. (Fig. 11c–e)

DESCRIPTION: Carapace small to medium sized, smooth, elongate-triangular. Dorsal margin broadly arched, ventral margin sinuous, incurved medially. Anterior broadly rounded, strongly depressed ventrally. Selvage peripheral except mid-ventrally. Duplicature wide throughout, widest anteriorly and posteriorly. Vestibules wide anteriorly, extremely wide posteriorly. Line of concrescence slightly sinuous anteriorly. Marginal pore canals numerous, straight, a few branched medially. Typical rosette muscle scar pattern faintly visible.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.58 mm; height 0.28 mm; width (entire carapace) 0.22 mm.

DISTRIBUTION: Common in outer shelf and canyon samples (50–500 m). Thanatocoenosis depth range: 140–300 m. Substrate: gravelly sand, sandy gravel (thanatocoenosis).

Genus ARGILLOECIA Sars, 1866

TYPE SPECIES: *Argilloecia cylindrica* Sars, 1866

Argilloecia sp. (Fig. 12a–c)

DESCRIPTION: Carapace of medium size, smooth and extremely thick, rhomboidal. Dorsal and ventral margins parallel, dorsal margin straight, ventral margin slightly sinuous. Posteroventral angle acute. Anterior curved broadly upwards. Duplicature wide and slightly irregular anteriorly and posteriorly. Hingement adont. Muscle scars typical for the genus.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.59 mm; height 0.28 mm; width (right valve) 0.17 mm.

DISTRIBUTION: Rare on inner shelf (0–50 m). Common in outermost shelf and canyon samples (100–500 m). Biocoenosis depth range: 105–400 m. Thanatocoenosis depth range: 150–200 m. Substrate: sandy gravel, gravelly sand, muddy sand (thanatocoenosis).

REMARKS: Characterised by a thick carapace with an acute posteroventral angle.

Argilloecia sp. aff. **A. pusilla** (Brady) (Fig. 12d)

1880 *Aglaia*(?) *pusilla* Brady, *Rep. scient. Results explor. Voyage Challenger 1(3)*: 34, pl. xxx, figs 6a d.

1969 *Argilloecia pusilla* (Brady). Maddocks, *Smithson. Contr. Zool. 7*: 46, figs 8h, 33g, h.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.52 mm; height 0.22 m; width (left valve) 0.19 mm.

DISTRIBUTION: Common in outer shelf and canyon samples (100–500 m).

REMARKS: Distinguished from *Argilloecia clavata* (Brady, 1880) by the strong slope of the anterodorsal margin and consequent narrow anterior. The lectotype of *A. pusilla* in the British Museum (Natural History) is distinctly smaller than Otago Shelf specimens.

Superfamily CYTHERACEA Baird, 1850

Family BYTHOCYTHERIDAE Sars, 1926

Genus BYTHOCYTHERE Sars, 1866

TYPE SPECIES: *Bythocythere turgida* Sars, 1866; subsequent designation by Brady & Norman, 1889

'Bythocythere' bulba n.sp. (Fig. 13)

DESCRIPTION: Carapace small-medium, subrectangular, venter strongly inflated. Dorsal and ventral margins subparallel. Anterior broadly rounded, posterior bluntly pointed. Median sulcus present. Carapace ornamented with a few large puncta. Striae occur posterodorsally and on the posteroventral extremity of the inflated area. Selvage peripheral except mid-ventrally. Duplicature widest posteriorly, wide anteriorly. Line of concrescence

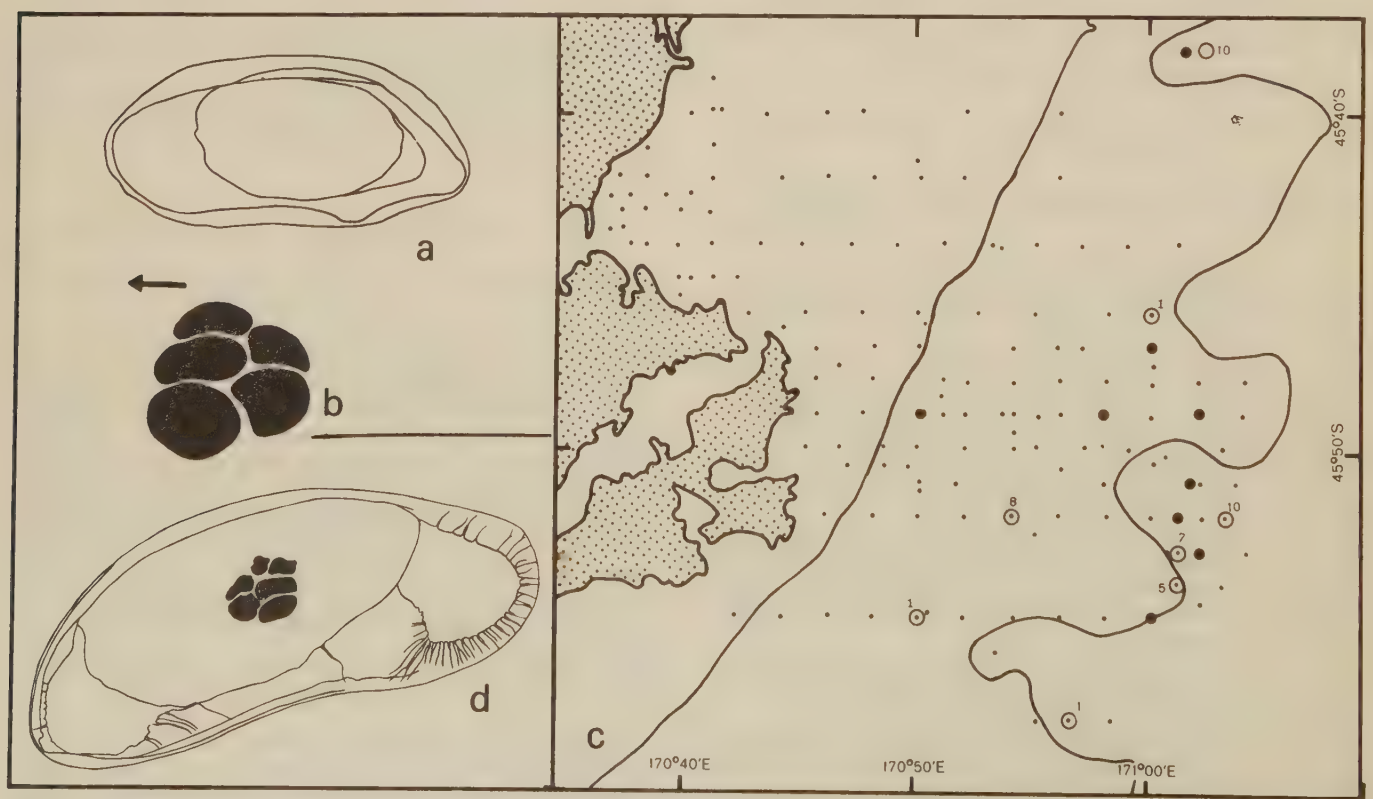


FIG. 12. *Argilloecia* sp. (N.Z. Geological Survey Cat. No. OP 1041): a, internal view of right valve, x 60; b, muscle scars, x 200; c, geographic distribution.
Argilloecia sp. aff. *A. pusilla* (Brady) (N.Z. Geological Survey Cat. No. OP 1036): d, internal view of left valve, x 120.

slightly sinuous anteriorly, thrown into a series of deep indentations posteriorly. Marginal pore canals straight, slightly sinuous (particularly posteriorly), a few branched. Hingement and muscle scars typical for the genus.

TYPES: N.Z. Geological Survey Cat. No TO 1020. Holotype and two paratypes. Mu 67-63, 321 m.

DIMENSIONS OF HOLOTYPE: Length 0.62 mm; height 0.31 mm; width (left valve) 0.18 mm.

DISTRIBUTION: Rare to common in outer shelf samples (50–100 m), rare in canyon samples (100–500 m). Thanatocoenosis depth range: 65–110 m. Substrate: gravelly muddy sand, muddy sandy gravel, sandy gravel (thanatocoenosis).

REMARKS: McKenzie (pers. comm.) is to propose a new bythocytherinid genus with *Bythocythere arenacea* Brady, 1880 as type species. The present species probably belongs to this genus.

Genus BYTHOCERATINA Hornibrook, 1952

TYPE SPECIES: *Bythoceratina mestayerae* Hornibrook, 1952

Bythoceratina decepta Hornibrook (Fig. 14a, b)

1952 *Bythoceratina decepta* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 63, pl. 16, figs 260-2.

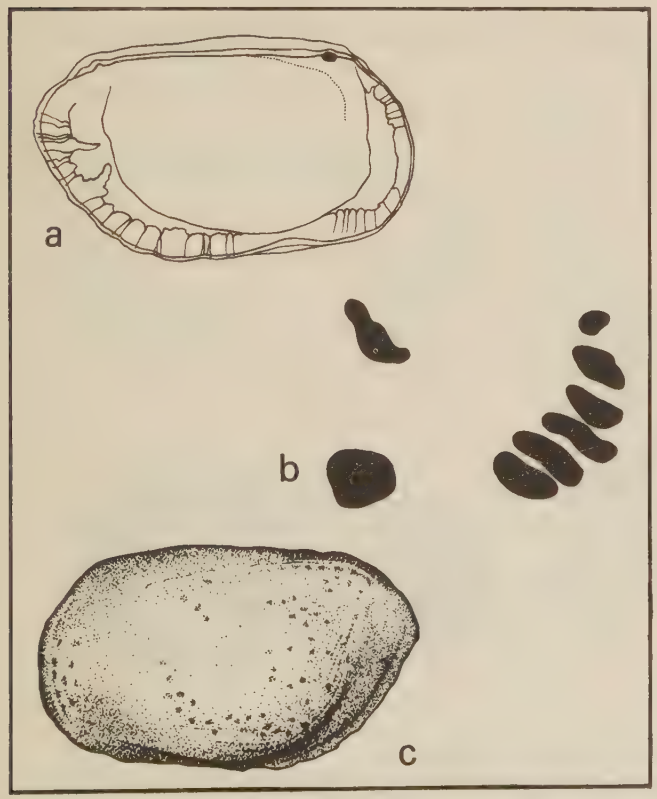


FIG. 13. *'Bythocythere' bulba* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1020): a, internal view of left valve, x 60; b, muscle scars, x 200; c, external view of left valve, x 60.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.61 mm; height 0.34 mm; width (right valve) 0.18 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. In the study area: rare in outer shelf and canyon samples (100–500 m).

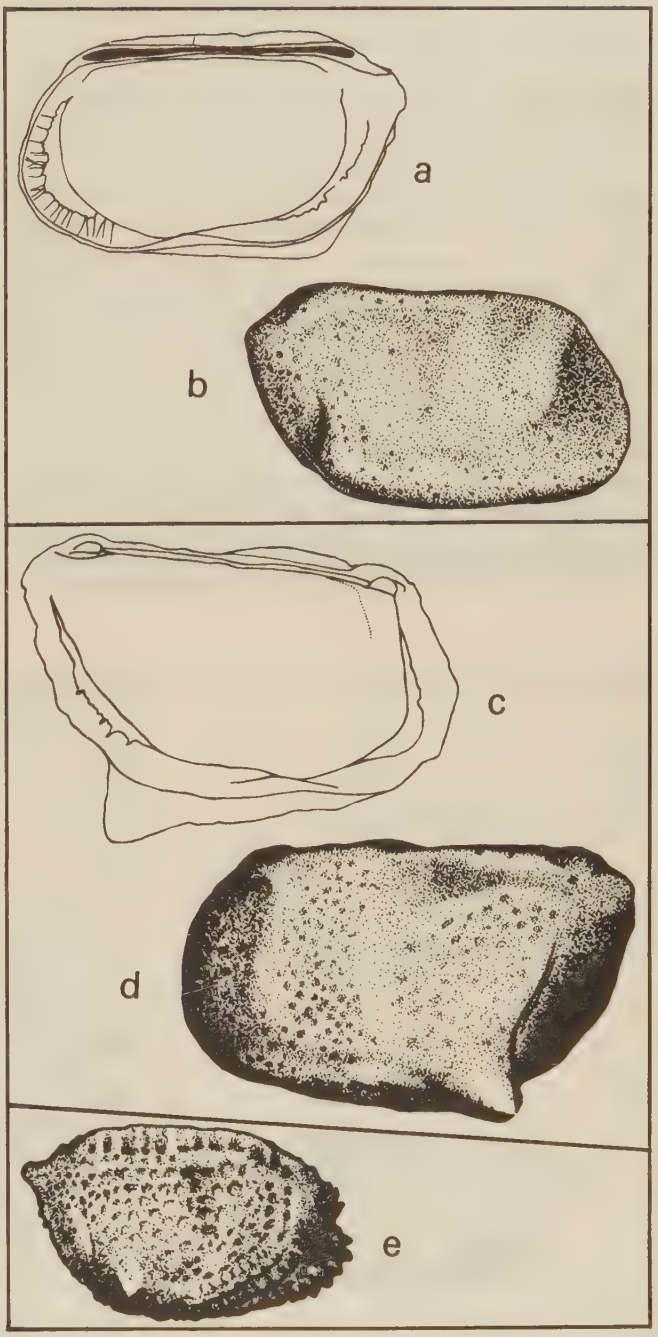


FIG. 14. *Bythoceratina decepta* Hornibrook (N.Z. Geological Survey Cat. No. OP 1043): a, internal view of right valve, x 60; b, external view of right valve, x 60.
Bythoceratina maoria Hornibrook (N.Z. Geological Survey Cat. No. OP 1044): c, internal view of left valve, x 60; d, external view of left valve, x 60.
Bythoceratina edwardsoni Hornibrook (N.Z. Geological Survey Cat. No. OP 1047): e, external view of right valve, x 60.

Bythoceratina maoria Hornibrook (Fig. 14c, d)

1952 *Bythoceratina maoria* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 63, pl. 16, figs 265, 267, 268

DIMENSIONS OF FIGURED SPECIMEN: Length 0.72 mm; height 0.43 mm; width (left valve) 0.33 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters.

Bythoceratina edwardsoni Hornibrook (Fig. 14e)

1952 *Bythoceratina edwardsoni* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 64, pl. 17, figs 273–5.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.60 mm; height 0.33 mm; width (right valve) 0.24 mm.

DISTRIBUTION: Hornibrook (1952) reported this species from southern waters of New Zealand. In the study area: rare in outer shelf and canyon samples (100–500 m).

Bythoceratina fragilis Hornibrook (Fig. 15)

1952 *Bythoceratina fragilis* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 64, pl. 16, figs 263, 264, 266.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.52 mm; height 0.26 mm; width (right valve) 0.17 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. In the study area: rare in outer shelf and canyon samples (100–500 m).

Bythoceratina tuberculata Hornibrook (Fig. 16)

1952 *Bythoceratina tuberculata* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 65, pl. 17, figs 276–8, 281.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.68 mm; height 0.32 mm; width (right valve) 0.28 mm.

DISTRIBUTION: Hornibrook (1952) reported this species from southern and south-eastern waters of New Zealand. Recorded throughout the study area. Thanatocoenosis depth range: 60–110 m. Substrate: gravelly muddy sand, muddy sandy gravel, sandy gravel (thanatocoenosis).

Genus MIRACYTHERE Hornibrook, 1952

TYPE SPECIES: *Miracythere novaspecta* Hornibrook, 1952

Miracythere novaspecta Hornibrook (Fig. 17)

1952 *Miracythere novaspecta* Hornibrook, *N.Z. geol. Surv. Paleont. Bull 18* : 61–62, pl. 15, figs 248–56.

DIMENSIONS OF FIGURED SPECIMEN: (juvenile). Length 0.62 mm; height 0.38 mm; width (right valve) 0.24 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. Rare in sample Mu 68-85, 182 m (this study).

FIG. 15. *Bythoceratina fragilis* Hornibrook (N.Z. Geological Survey Cat. No. OP 1042): a, internal view of right valve, x 60; b, external view of right valve, x 60; c, geographic distribution.

Genus PSEUDOCYTHERE Sars, 1866

Subgenus PSEUDOCYTHERE Sars, 1866

TYPE SPECIES: *Pseudocythere caudata* Sars, 1866

Pseudocythere (Pseudocythere) cf. **P. (P.) caudata** Sars (Fig. 18)

1866 *Pseudocythere caudata* Sars, Forh. *Videnskselsk. Krist.* 7: 239, pl. CIX, fig. 2.

See Neale (1967, p. 14) for a more complete synonymy.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.50 mm; height 0.29 mm; width (entire carapace) 0.20 mm.

DISTRIBUTION: Common in outermost shelf and canyon samples (100–500 m), extremely rare on inner shelf (0–50 m). Thanatocoenosis depth range: 170–?325 m. Substrate: gravelly sand (thanatocoenosis).

REMARKS: Van Morkhoven (1963, p. 425) refers to an apparent reversal of hingement in species of this genus. Examination of a large number of specimens of *Pseudocythere caudata* from the Norman Collection (British Museum (Natural History)) and those of the Otago Shelf has shown that large variations in the number of marginal pores and in the hingement, including reversals, are possible even within relatively small geographic areas (*see* Fig. 18a).

Subgenus PLENOCYTHERE n. subgen.

TYPE SPECIES: *Pseudocythere (Plenocythere) fragilis* n.sp.

DESCRIPTION: A bythocytherinid subgenus characterised by a large, inflated, elongate, extremely thin carapace. Carapace evenly rounded with maximum inflation ventromedially. Caudal process flattened, occurring mid-posteriorly or slightly above that point. Duplicature extremely wide throughout, particularly anteriorly and posteriorly. Vestibules well developed anteriorly and posteriorly. Line of concrescence irregular anteriorly and in the zone directly forward of the caudal process. Marginal pore canals numerous (85–90), mostly short, longer mid-ventrally. Few show median thickenings and/or branching. Muscle scars, a vertical row of five adductor scars with an irregularly shaped frontal scar.

REMARKS: Closely related to *Pseudocythere* sensu stricto but easily distinguished by the following characteristics: more inflated shape, numerous marginal pore canals, a weakly developed ventrolateral keel, and the positioning of the caudal process mid-posteriorly rather than dorsally as occurs in *Pseudocythere (Pseudocythere)*. At present the subgenus contains only one species. *Pseudocythere fuegiensis* Brady, 1880 (*Challenger* Collection No. 81.5.54, British Museum (Natural History)) has some affinities with this new subgenus. A fragment of another species of this subgenus was found in one Otago Shelf sample.

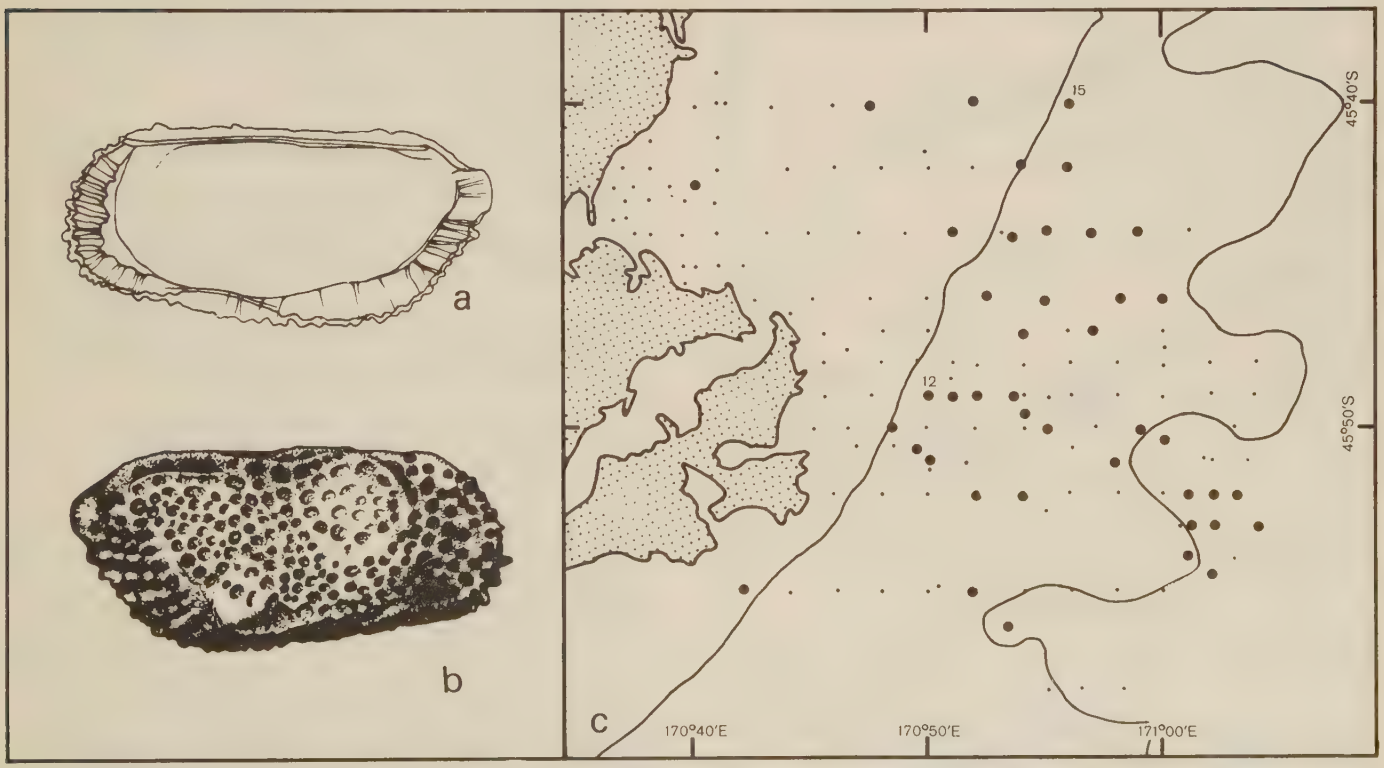


FIG. 16. *Bythoceratina tuberculata* Hornibrook (N.Z. Geological Survey Cat. No. OP 1045): a, internal view of right valve, x 60; b, external view of right valve, x 60; c, geographic distribution.

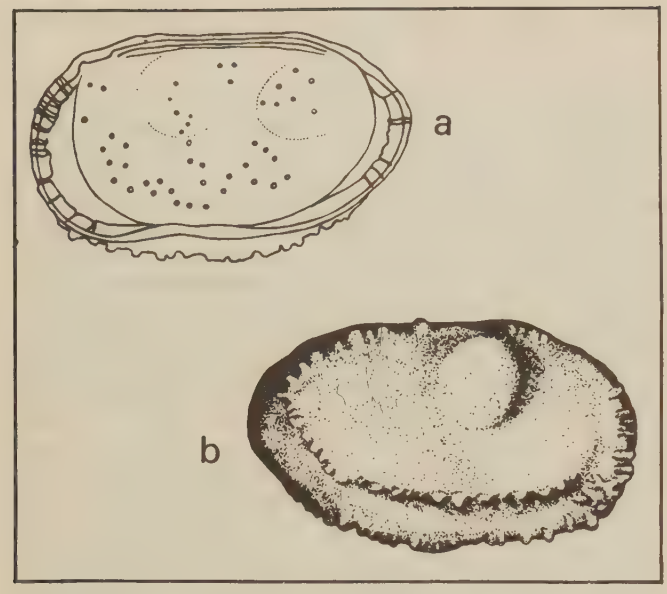
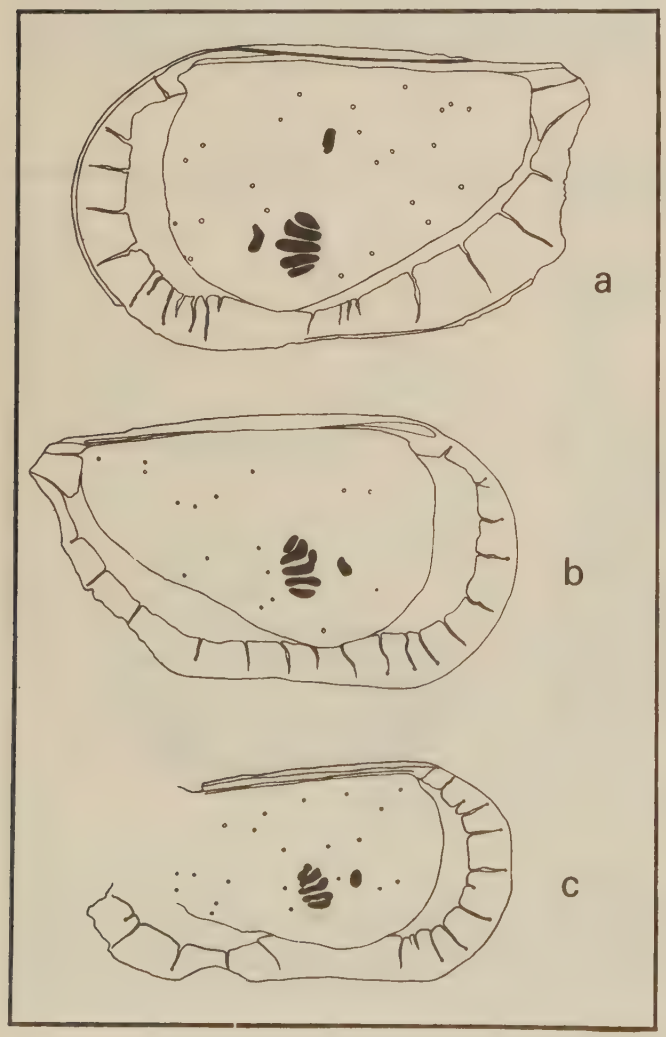


FIG. 17. *Miracythere novaspecta* Hornibrook (N.Z. Geological Survey Cat. No. OP 1046): a, internal view of right valve, x 60; b, external view of right valve, x 60.



Pseudocythere (Plenocythere) fragilis n.sp. (Fig. 19)

DESCRIPTION: Carapace large, smooth, and extremely thin. Greatest inflation ventromedially. Dorsal margin broadly arched, ventral margin strongly convex. Ventrolateral keel weak. Anterior broadly rounded, posterior upturned connecting with a broad, flattened caudal process. Duplicature extremely wide anteriorly and posteriorly. Vestibules well developed anteriorly and posteriorly. Line of concrescence with pronounced irregularities anteriorly and posteriorly. Marginal pore canals numerous (85+), short anteriorly and posteriorly, considerably longer mid-ventrally. A few display median thickenings and/or branching. Approximately seven pore canals extend through the caudal process, the most ventral of this group appears much larger. Muscle scars: a vertical group of five adductor scars with an irregularly shaped frontal scar. Hingement: left valve with a thin dorsal ridge, right valve with equivalent groove.

TYPES: N.Z. Geological Survey Cat. No. TO 1019, Holotype and four paratypes. Mu 67-44, 163 m.

DIMENSIONS OF HOLOTYPE: Length 0.68 mm; height 0.35 mm; width (left valve) 0.18 mm.

DISTRIBUTION: Rare occurrences in outer shelf and canyon samples (100–500 m).

REMARKS: Distinctly more like *Pseudocythere* in outline than *Antarcticythere* Neale, 1967 and lacking the dorsal overlap in left valve.

Genus CYTHERALISON Hornibrook, 1952

TYPE SPECIES: *Cytheralison fava* Hornibrook, 1952

Cytheralison fava Hornibrook (Fig. 20)

1952 *Cytheralison fava* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 66, pl. 18, figs 283, 284, 287, 289

1969 *Cytheralison fava* Hornibrook. Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)* : 47.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.88 mm; height 0.47 mm; width (right valve) 0.27 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. In the study area : rare in outer shelf and canyon samples (100–500 m).

Family CYTHERIDAE Baird, 1850

Subfamily CYTHERINAE Baird, 1850

Tribe CYTHERINI Baird, 1850

Genus LOXOCYTHERE Hornibrook, 1952

TYPE SPECIES: *Loxocythere crassa* Hornibrook, 1952

FIG. 18. *Pseudocythere (Pseudocythere)* cf. *P. (P.) caudata* Sars (N.Z. Geological Survey Cat. No. OP 1035): internal views of two separate (female?) valves showing variation in hinge structure, a, right valve; b, left valve. c, specimen from Stn 30, 3–25 fathoms, Norman Collection, British Museum of Natural History.

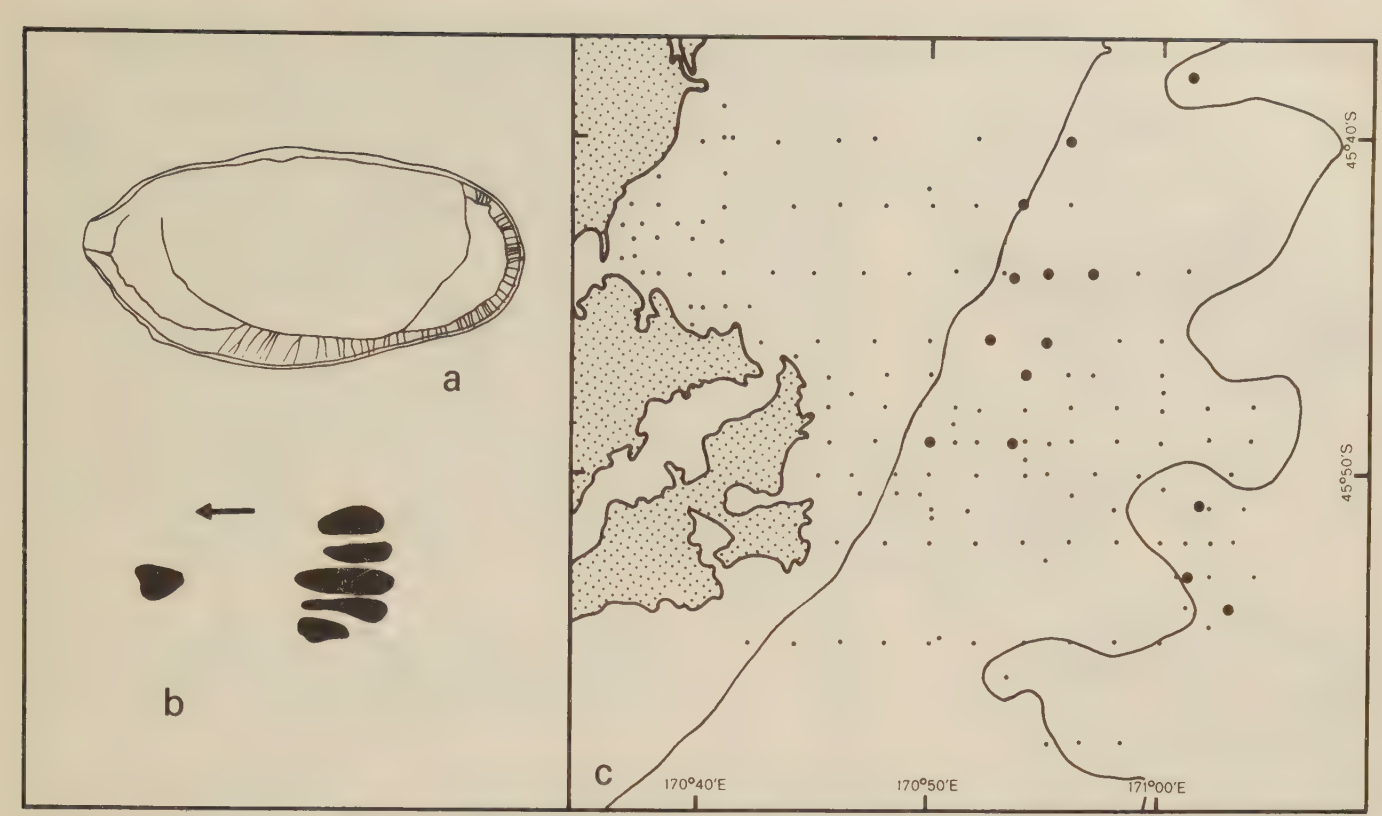


FIG. 19. *Pseudocythere (Pienocythere) fragilis* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1019): a, internal view of left valve, x 60; b, muscle scars, x 200; c, geographic distribution.

Loxocythere crassa Hornibrook (Fig. 21)

1952 *Loxocythere crassa* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 30, pl. 2, figs 26–31.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.52 mm; height 0.35 mm; width (left valve) 0.19 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. Found throughout the study area. Biocoenosis depth range: 25–45 m. Thanatocoenosis depth range: 6–45 m. Substrate: sand, muddy sand (biocoenosis).

Tribe PECTOCYTHERINI Hanai, 1957

Genus MUNSEYELLA van den Bold, 1957

TYPE SPECIES: *Toulminia hyalokystis* Munsey, 1953

Munseyella brevis n.sp. (Fig. 22)

DESCRIPTION: Carapace small, subquadrate, and thick. Dorsal margin sinuous, ventral margin straight. Posterior squarely truncated; anterior broadly rounded, slightly depressed ventrally. Anterodorsal angle characterised by the presence of a short, bulbous lobe. Anteromarginal ridge strong, extending to much weaker ventral and posteromarginal ridges. Secondary ridge systems occur medially and dorsally. Interior typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1024. Holotype and six paratypes. Mu 69-32, 28 m.

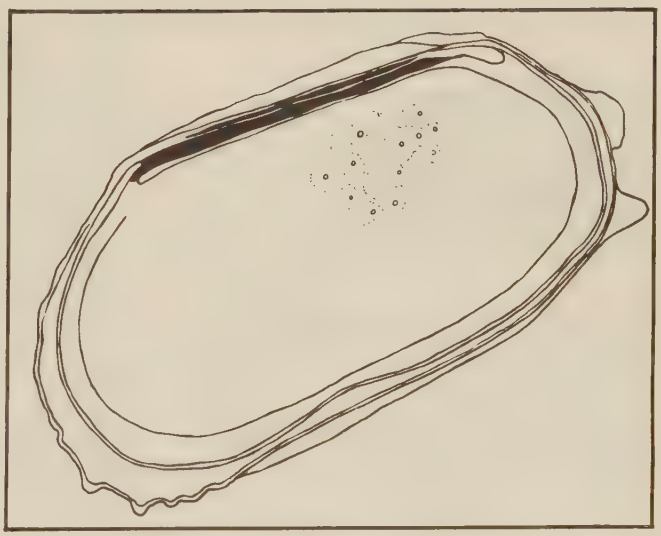


FIG. 20. *Cytheralison fava* Hornibrook (N.Z. Geological Survey Cat. No. OP 1071): internal view of right valve, x 100.

DIMENSIONS OF HOLOTYPE: Length 0.37 mm; height 0.22 mm; width (left valve) 0.09 mm.

DISTRIBUTION: Occurs throughout the study area. Rare in both inner shelf and canyon samples. Biocoenosis depth range: 50–95 m. Thanatocoenosis depth range: 35–104 m. Substrate: muddy sand, gravelly muddy sand, muddy sandy gravel (biocoenosis).

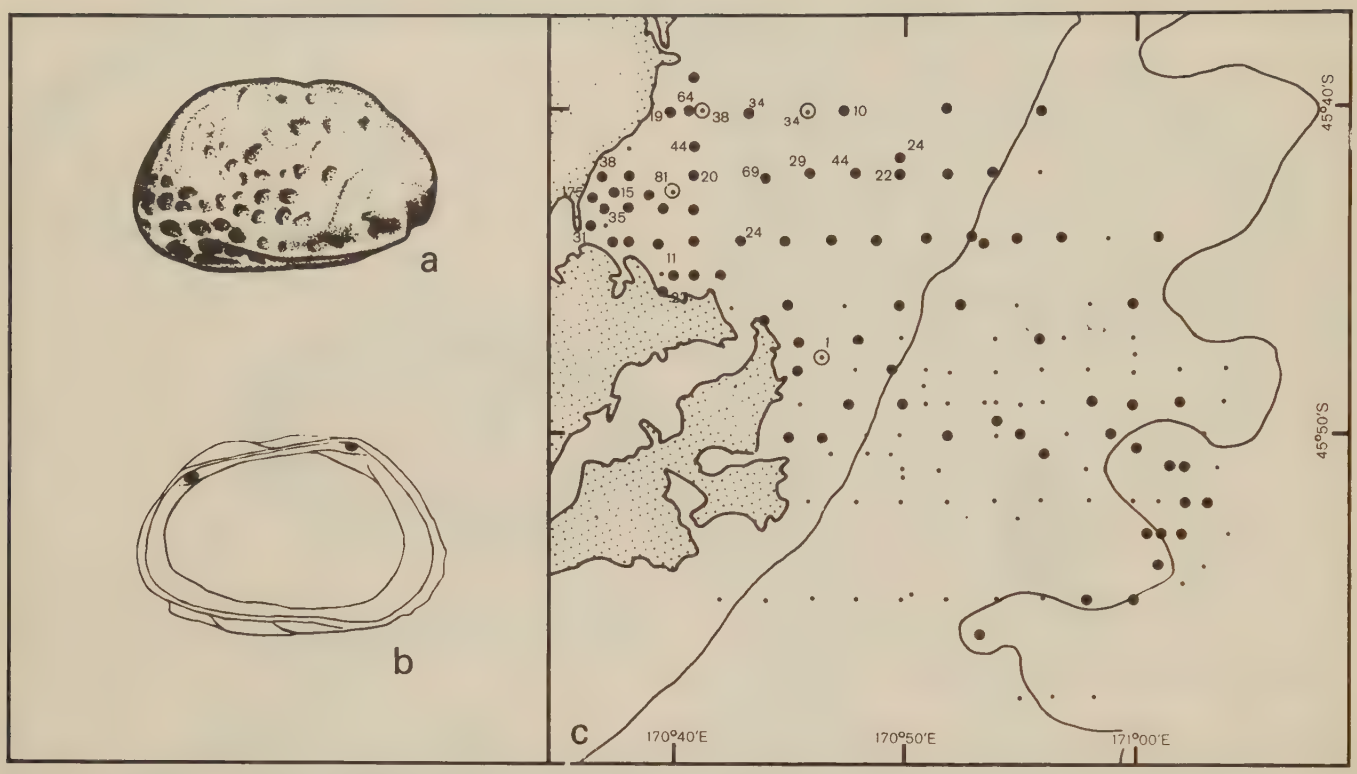


FIG. 21. *Loxocythere crassa* Hornibrook (N.Z. Geological Survey Cat. No. OP 1048): a, external view of left valve, x 60; b, internal view of left valve, x 60; c, geographic distribution.

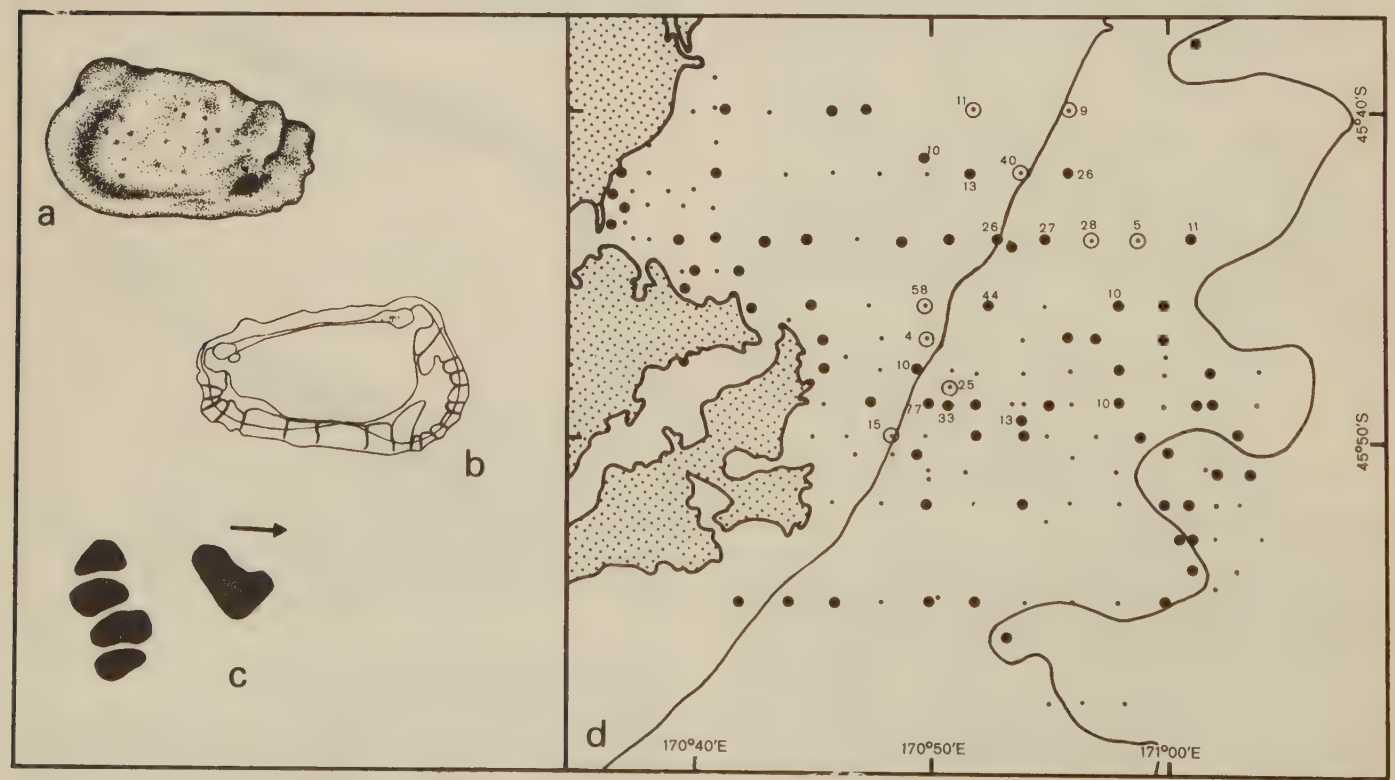


FIG. 22. *Munseyella brevis* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1024): a, external view of female left valve, x 60; b, internal view of female left valve, x 60; c, muscle scars, x 200; d, geographic distribution.

'Munseyella' aequa n.sp. (Fig. 23a, b)

DESCRIPTION: Carapace thick and elongate. Dorsal margin straight, ventral margin incurved. Anterior broadly rounded, depressed ventrally; posterior truncated, slightly depressed ventrally. Anterior and posterior marginal ridges strongly developed. Carapace ornamented with a series of shallow, irregularly spaced reticulations. Carapace carries two distinct spines on the posterior similar to those described by Ishizaki (1966). Selvage strong, peripheral throughout. Duplicature widest anteriorly. Vestibules well developed posteriorly, more so anteriorly. Anterior vestibule with strong dorsal indentation. Marginal pore canals few, straight and simple. Hingement typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1025. Holotype and eight paratypes. Mu 67-140, 63 m.

DIMENSIONS OF HOLOTYPE: Length 0.50 mm; height 0.22 mm; width (left valve) 0.10 mm.

DISTRIBUTION: Rare occurrences throughout the study area.

REMARKS: Similar in shape to *Munseyella hatatatensis* Ishizaki, 1966. On *M. aequa*, however, the posterior and anterior thirds of the carapace are considerably flattened, both margins having extremely deep marginal grooves.

Munseyella modesta n.sp. (Fig. 23c, d)

DESCRIPTION: Carapace small, subrectangular. Dorsal margin straight, ventral margin slightly incurved medially. Anterior broadly rounded, posterior squarely truncated. Antero- and posteromarginal ridges moderately well developed. Carapace ornamented with a series of irregularly shaped reticulations. Posterior extended ventrally forming a small keel. Selvage subperipheral posteriorly, peripheral anteriorly. Duplicature extremely wide, widest anteroventrally. Vestibules well developed. Line of concrescence slightly serrate anteriorly. Approximately 40 marginal pore canals, straight and simple.

TYPES: N.Z. Geological Survey Cat. No. TO 1027. Holotype and eight paratypes. Mu 68-45, 140 m.

DIMENSIONS OF HOLOTYPE: Length 0.46 mm; height 0.23 mm; width (right valve) 0.12 mm.

DISTRIBUTION: Occurs in three samples only: Mu 67-140, 63 m; Mu 68-45, 140 m; Mu 68-27, 630 m.

'Munseyella' tumida n.sp. (Fig. 24)

DESCRIPTION: Carapace small, elongate, and thin. Dorsal margin slightly sinuous, ventral margin strongly incurved medially. Anterior broadly rounded, slightly depressed ventrally. Posterior truncated, with two weakly developed spines. Carapace ornamented with a series of small, deep, regularly spaced reticulations. Posterior and anterior marginal ridges present. Duplicature widest anteriorly, wide posteriorly. Vestibule extremely wide anteriorly. Line of concrescence strongly indented at the anteroventral angle. Hingement and muscle scars typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1028. Holotype and 11 paratypes. Mu 69-71, 110 m.

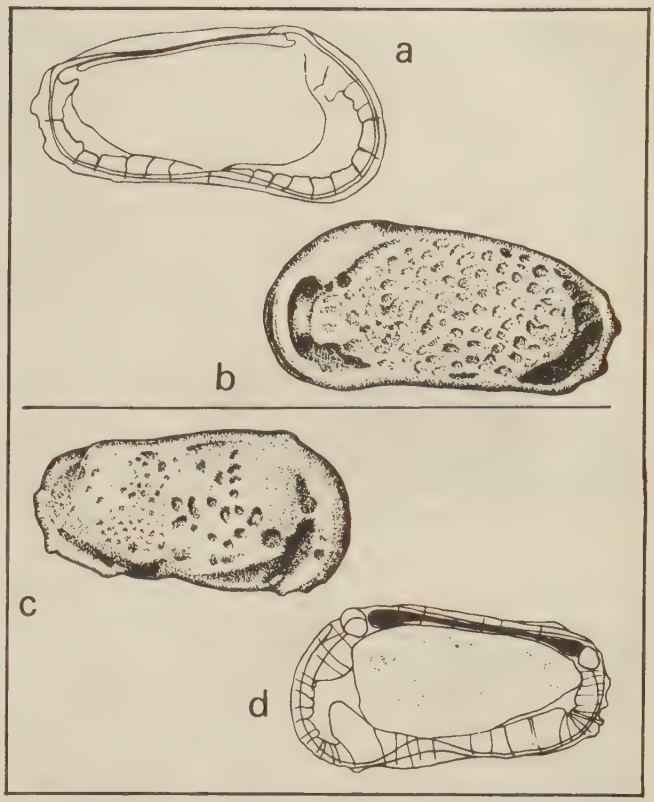


FIG. 23. *'Munseyella' aequa* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1025): a, internal view of male left valve, x 60; b, external view of male left valve, x 60.
Munseyella modesta n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1027): c, external view of (male?) right valve, x 60; d, internal view of (male?) right valve, x 60.

DIMENSIONS OF HOLOTYPE: Length 0.41 mm; height 0.22 mm; width (left valve) 0.12 mm.

DISTRIBUTION: Occurs throughout the study area. Rare on the inner shelf (0–50 m). Biocoenosis depth range: 54–84 m. Thanatocoenosis depth range: 35–105 m. Substrate: muddy sand, gravelly muddy sand, gravelly sand, muddy sandy gravel (biocoenosis).

REMARKS: Distinguished from *'Munseyella' aequa* by the weak marginal ridge and the indented line of concrescence. Reticulations are more clearly defined on *'Munseyella' tumida*. *'Munseyella' aequa* and *'M.' tumida* are rather peculiar elongate pectocytherinid forms. With the discovery of more such species from the Pacific it may be possible to separate this group from *Munseyella* on the basis of variations in the line of concrescence and marginal pore canals.

Genus KOTORACYTHERE Ishizaki, 1966

TYPE SPECIES: *Kotoracythere abnorma* Ishizaki, 1966

Kotoracythere formosa n.sp. (Fig. 25)

DESCRIPTION: Carapace thick, elongate, and well proportioned. Dorsal margin slightly sinuous, ventral margin slightly incurved. Anterior broadly rounded,

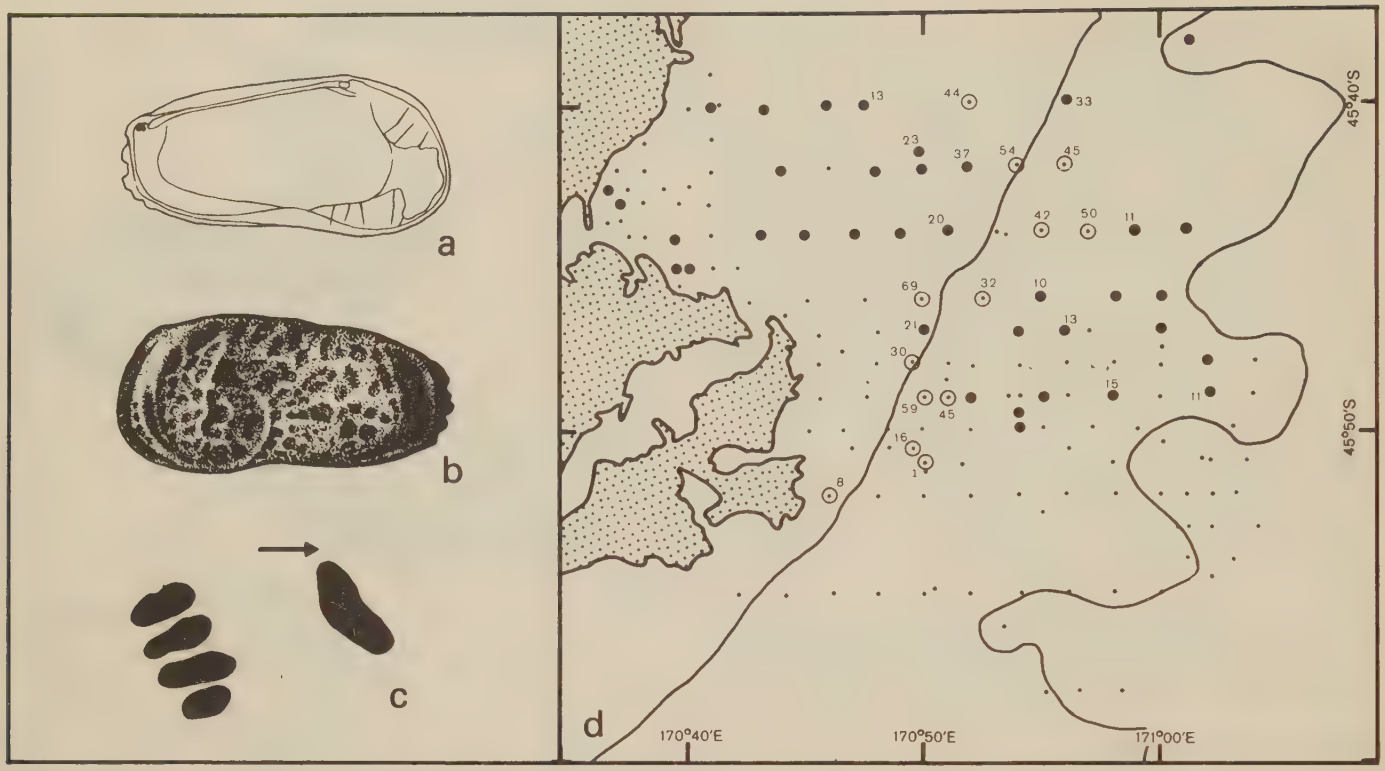


FIG. 24. *'Munseyella' tumida* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1028): a, internal view of (female?) left valve, x 60; b, external view of (female?) left valve, x 60; c, muscle scars, x 200; d, geographic distribution.

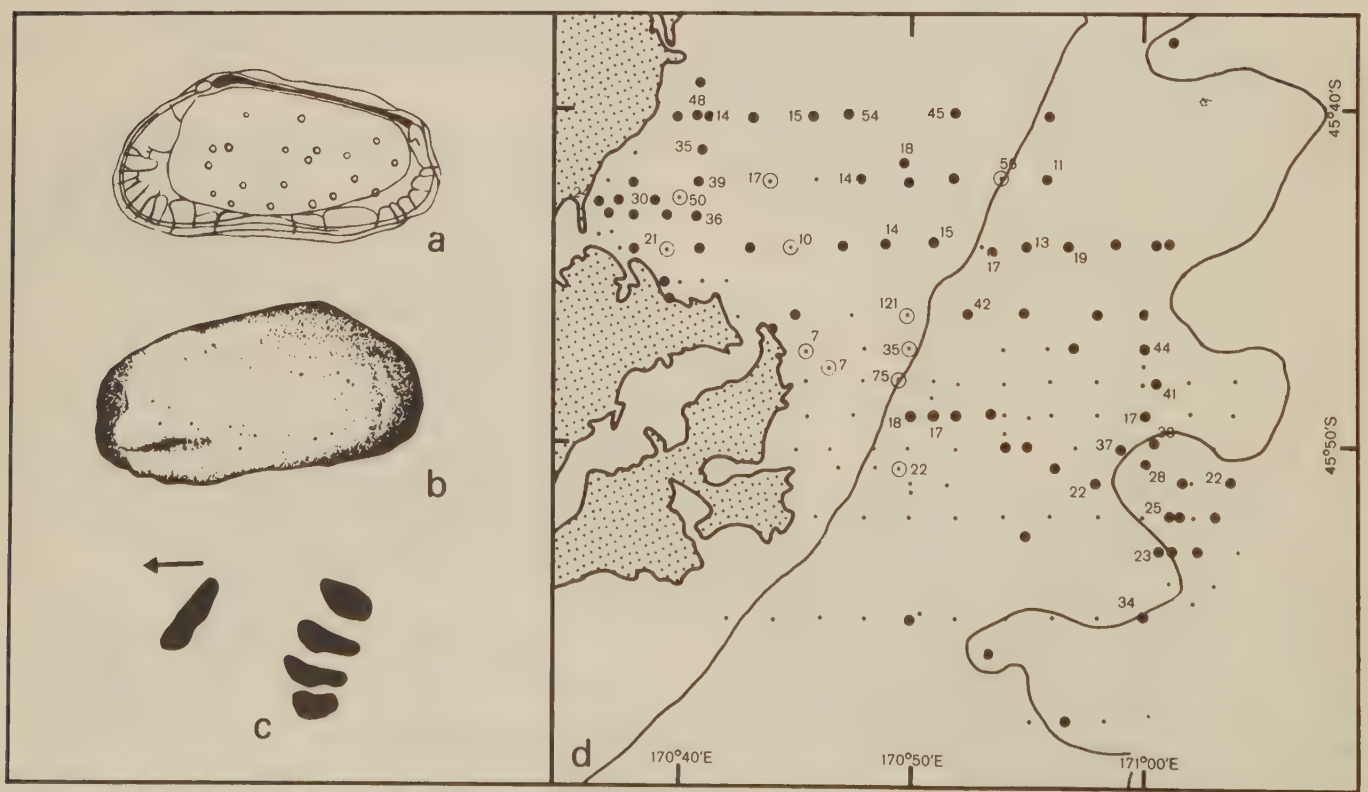


FIG. 25. *Kotoracythere formosa* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1026): a, internal view of (female?) right valve, x 60; b, external view of (female?) right valve, x 60; c, muscle scars, x 200; d, geographic distribution.

depressed ventrally. Posterior sharply truncated. Externally carapace dominated by a 'wing like' projection extending posteriorly from the median area. Remainder of the carapace almost smooth except for a few shallow reticulations and a weakly developed anteromarginal ridge. Duplicature wide anteriorly and posteroventrally. Vestibules well developed antero- and posteroventrally. Marginal pore canals few; straight, and often extremely wide. Normal pores few and prominent. Hingement and muscle scars typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1026. Holotype and ten paratypes. Mu 66-13, 30 m.

DIMENSIONS OF HOLOTYPE: Length 0.44 mm; height 0.22 mm; width (right valve) 0.11 mm.

DISTRIBUTION: Occurs throughout the study area. Biocoenosis depth range: 0–55 m. Thanatocoenosis depth range: 0–65 m. Substrate: muddy sand, sand, gravelly muddy sand, muddy sand, muddy sandy gravel, sandy gravel (biocoenosis).

Family LEPTOCYTHERIDAE Hanai, 1957

Genus CALLISTOCYTHERE Ruggieri, 1953

TYPE SPECIES: *Cythere littoralis* Mueller, 1894

Callistocythere neoplana n.sp. (Fig. 26a–d)

DESCRIPTION: Carapace subquadrate, thick and rotund. Dorsal and ventral margins subparallel. Ventral margin slightly incurved, dorsal margin sinuous. Anterior broadly rounded, depressed ventrally. Posterior squarely truncated. Carapace smooth with minor ridge systems along the dorsal and ventral margins. Duplicature extremely wide anteriorly and posteroventrally. Selvage subperipheral, moderately strong. Line of concrescence and marginal pore canals typical for the genus. Hingement typical for the genus, anterior tooth crescent shaped. Muscle scars typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1023. Holotype and nine paratypes. Mu 68-80, 6 m.

DIMENSIONS OF HOLOTYPE: Length 0.46 mm; height 0.30 mm; width (left valve) 0.12 mm.

DISTRIBUTION: Common on inner shelf (0–50 m), rare in outer shelf and canyon samples (100–500 m). Biocoenosis depth range: 0–28 m. Thanatocoenosis depth range: 0–18 m. Substrate: sand, muddy sand (biocoenosis).

Callistocythere obtusa n.sp. (Fig. 26e, f)

DESCRIPTION: Carapace small and thick. Greatest height dorsoanteriorly with dorsal and ventral margins tapering sharply backwards. Anterior broadly rounded, posterior strongly up-turned. Carapace thin from dorsal aspect. Surface ornamentation dominated by a series of strong posterior ridges. Two such ridges extend from the posterior margin to the ventral margin and continue parallel to it for about two-thirds of the carapace. A third ridge occurs at the beginning of the posterior third

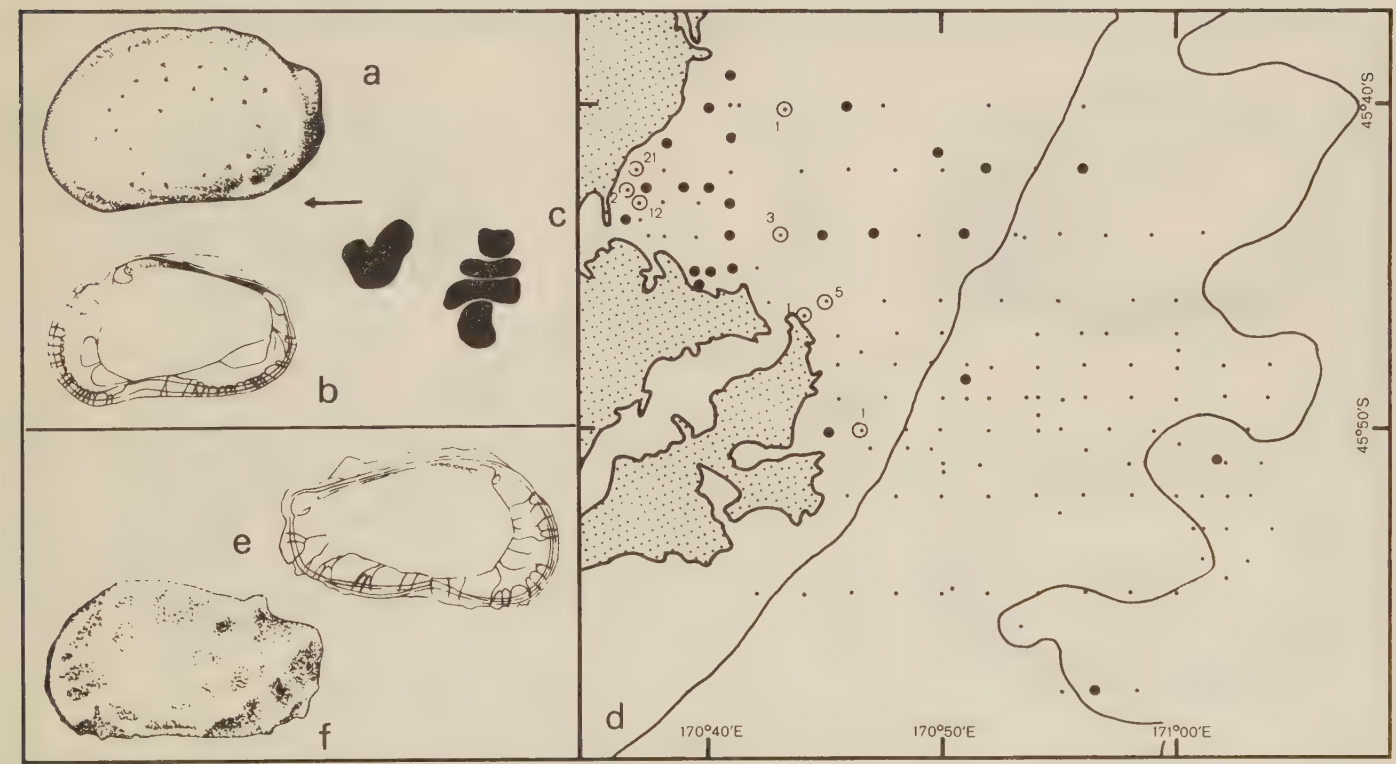


FIG. 26. *Callistocythere neoplana* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1023): a, external view of female left valve, x 60; b, internal view of (female?) right valve, x 60; c, muscle scars, x 200; d, geographic distribution.
Callistocythere obtusa n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1022): e, internal view of (male?) left valve, x 60; f, external view of (male?) left valve, x 60.

of the dorsal margin and extends ventrally for about one-third of the carapace height forming a circular structure, higher in the posterior half. Internally the carapace is typical of the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1022. Holotype and six paratypes. Mu 68-80, 6 m.

DIMENSIONS OF HOLOTYPE: Length 0.44 mm; height 0.25 mm; width (left valve) 0.10 mm.

DISTRIBUTION: Occurs throughout the study area. Thanatocoenosis depth range: 115–400 m. Substrate: gravelly sand, gravelly muddy sand (thanatocoenosis).

Family HEMICYTHERIDAE, Puri 1953

Subfamily HEMICYTHERINAE Puri, 1953

Tribe HEMICYTHERINI Puri, 1953

Genus HEMICYTHERE Sars, 1925

TYPE SPECIES: *Cythereis villosa* Sars, 1866

Hemicythere munida n.sp. (Fig. 27)

DESCRIPTION: Carapace thick, subquadrate. Dorsal margin slightly sinuous, ventral margin convex. Anterior broadly rounded, slightly depressed ventrally. Carapace highest slightly posterior of middle. Ornamented with coarse reticulations, prominent posteriorly and ventrally. Selvage strong. Duplicature of medium width throughout. Marginal pore canals generally straight, concentrated anteriorly, a few branched. Hingement and muscle scars typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1021. Holotype and six paratypes. Mu 67-44, 163 m.

DIMENSIONS OF HOLOTYPE: Length 0.69 mm; height 0.42 mm; width (left valve) 0.22 mm.

DISTRIBUTION: Occurs throughout the study area. Biocoenosis depth range: 0–?50 m. Thanatocoenosis depth range: 45–175 m. Substrate: sand (biocoenosis).

REMARKS: Characterised by a large, thick subquadrate carapace with heavy punctations and a weakly developed caudal process. The carina occurs posterodorsally and probably represents external reinforcement of the posterior hinge elements.

Subfamily THAEROCYTHERINAE Hazel, 1967

Tribe BRADLEYINI Benson, 1972

Genus QUADRACYTHERE Hornibrook, 1952

TYPE SPECIES: *Cythere truncula* Brady, 1898

Quadracythere truncula (Brady) (Fig. 28)

1898 *Cythere truncula* Brady, *Trans. zool. Soc. Lond. 14*: 444, pl. 57, figs 16, 17.

1952 *Quadracythere truncula* (Brady). Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 44, pl. 8, figs 107, 108, 114.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.56 mm;

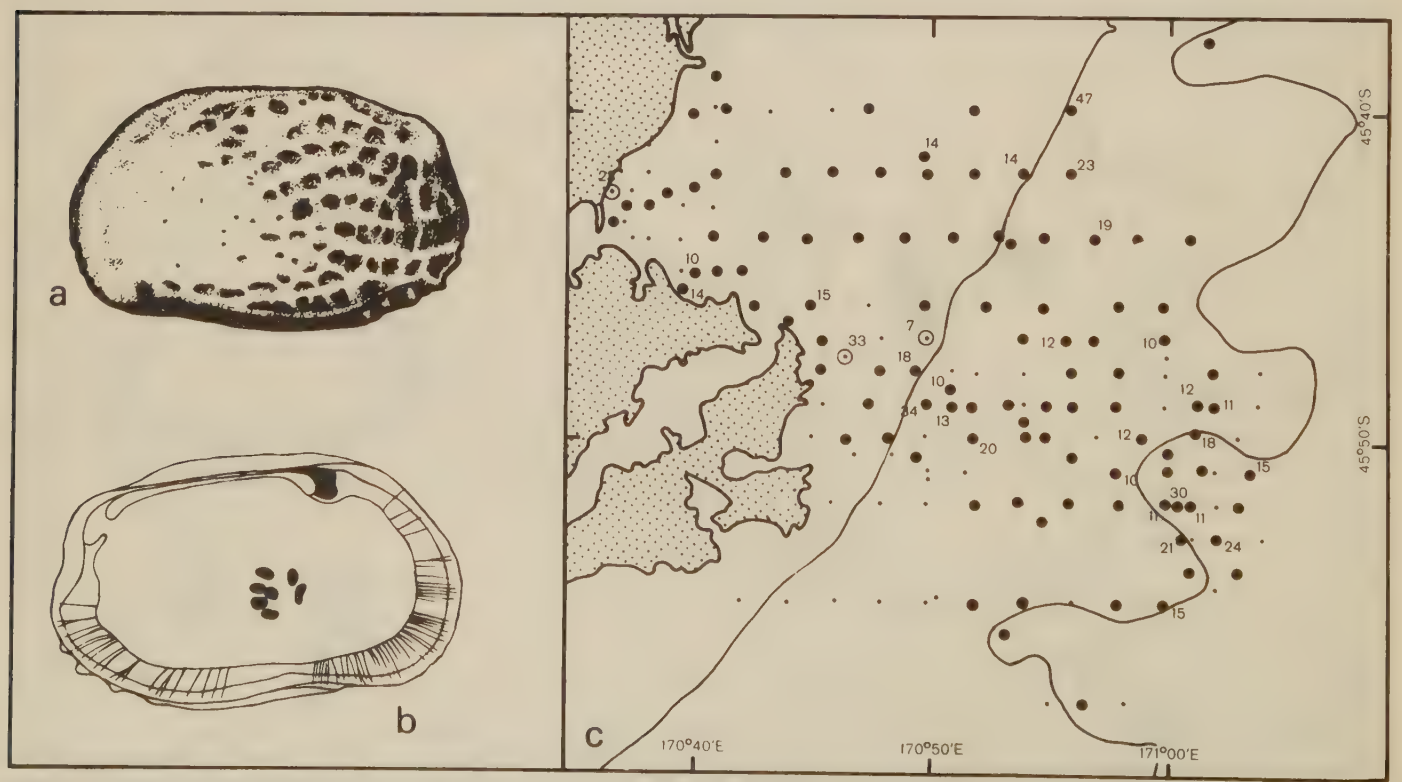


FIG. 27. *Hemicythere munida* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1021): a, external view of left valve, x 60; b, internal view of left valve, x 60; c, geographic distribution.

height 0.36 mm; width (right valve) 0.16 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. Found throughout the study area. Thanatocoenosis depth range: 40–85 m. Substrate: sand, gravelly muddy sand, gravelly sand, muddy sandy gravel, sandy gravel (thanatocoenosis).

Genus BRADLEYA Hornibrook, 1952

TYPE SPECIES: *Cythere arata* Brady, 1880

Bradleya opima n.sp. (Fig. 29)

DESCRIPTION: Carapace large, quadrate, and extremely thick. Dorsal margin straight, ventral margin convex. Anterior broad and evenly rounded; posterior blunt, almost flat, posterodorsal cardinal angle pronounced (obtuse). Carapace ornamented with a series of heavy, irregularly shaped, regularly spaced reticulations. Reticulations occurring around the anterior, anterodorsal, and ventral margins generally less clearly defined. Marginal carina prominent. Marginal denticulations present anteroventrally and posteriorly. Subcentral tubercle very weakly developed. Interior. duplicature wide throughout. Selvage strong, peripheral anteriorly and posteriorly, subperipheral ventrally. Vestibules present, narrow. Marginal pore canals few, straight and simple. Hingement typical for the genus.

TYPES: N.Z. Geological Survey Cat. No. TO 1038. Holotype and four paratypes. Mu 68-85, 182 m.

DIMENSIONS: Length 0.83 mm; height 0.50 mm; width (left valve) 0.19 mm.

DISTRIBUTION: Rare on outermost shelf (100–150 m), rare to common in canyon samples (150–500 m).

Tribe THAEROCYTHERIŃAE Hazel, 1967

Genus HERMANITES Puri, 1955

TYPE SPECIES: *Hermania reticulata* Puri, 1953

Hermanites andrewsi n.sp. (Fig. 30)

DESCRIPTION: Carapace small, subquadrate. Dorsal margin straight, ventral margin slightly sinuous. Anterior broadly rounded; posterior acute, greatest extension mid-posteriorly. Anterior marginal ridge strong. Dorsal ridge weak, ventral ridge slightly stronger; both ridges terminate posteriorly in strong bulbous processes. Subcentral tubercle extremely strong. Entire carapace, excluding the subcentral tubercle and marginal areas, ornamented with a series of small deep reticulations. Four to five spines present posteroventrally. Anterior marginal denticulations present. Eye spots clearly present. Interior: all hinge elements strongly developed. Posterior and particularly the anterior socket large. A strong median ridge with a large simple tooth at its anterior extremity. Duplicature of moderate width. Selvage peripheral throughout. Line of concrescence and inner margin coincide. Approximately 70 marginal

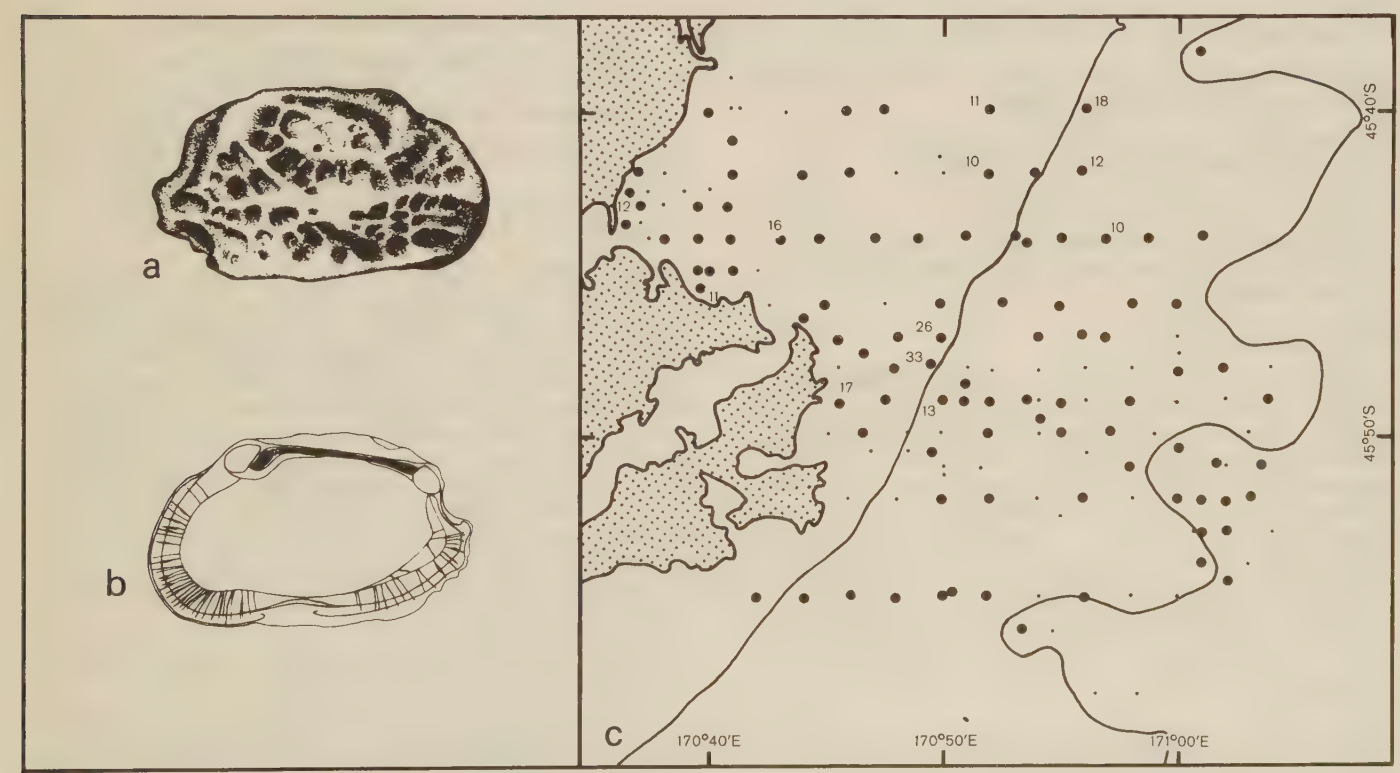


FIG. 28. *Quadracythere truncula* (Brady) (N.Z. Geological Survey Cat. No. OP 1051): a, external view of right valve, x 60; b, internal view of right valve, x 60; c, geographic distribution.

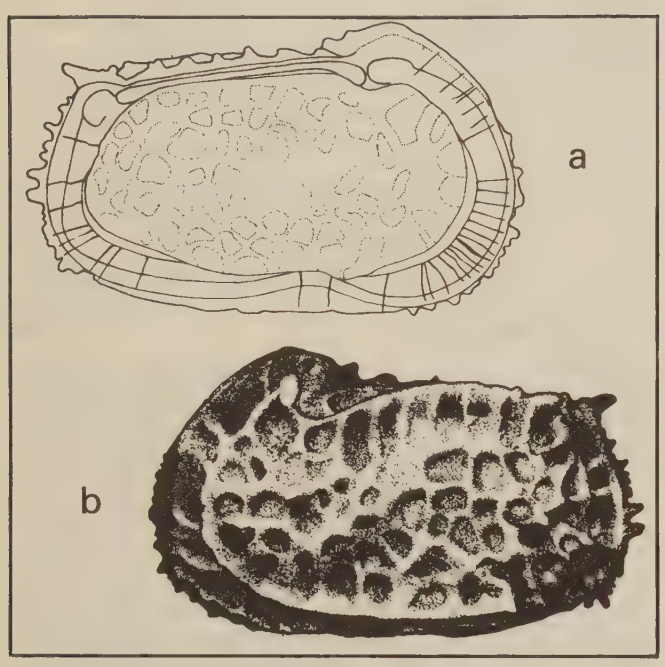


FIG. 29. *Bradleya opima* n.sp. (N.Z. Geological Survey Cat. No. OP 1052): a, internal view of left valve, x 100; b, external view of left valve, x 100.

pores, mostly straight, some branched and/or with median thickenings.

TYPES: N.Z. Geological Survey Cat. No. TO 1033. Holotype and one paratype. Mu 67-44, 163 m.

DIMENSIONS OF HOLOTYPE: Length 0.51 mm; height 0.25 mm; width (left valve) 0.11 mm.

DISTRIBUTION: Occurs in three samples only: Mu 69-45, 151 m; Mu 67-44, 163 m; Mu 67-81, 430 m.

REMARKS: A species characterised by a strongly developed subcentral tubercle, exaggerated extremities on both the posterodorsal and ventral margins, and small but deep reticulations.

Hermanites briggsi n.sp. (Fig. 31)

DESCRIPTION: Carapace large, thick, subquadrate, elongate. Dorsal and ventral margins straight, subparallel. Anterior broadly rounded. Subcentral tubercle present. Anteromarginal ridge prominent. Carapace ornamented with large heavy reticulations. Mid- and posterodorsal reticulations generally larger. Ventro- and dorsolateral ridges present. Marginal denticulations occur anteriorly; 4–5 prominent posteroventral spines also present. Interior: duplicature wide throughout. Selvage strong and peripheral. (Note presence of 'anti slip' device mid-ventrally (Fig. 31a)). Marginal pore canals numerous, straight, and simple, a few with median thickenings.

TYPES: N.Z. Geological Survey Cat. No. TO 1030. Holotype and nine paratypes. Mu 67-44, 163 m.

DIMENSIONS OF HOLOTYPE: Length 0.65 mm; height 0.32 mm; width (left valve) 0.14 mm.

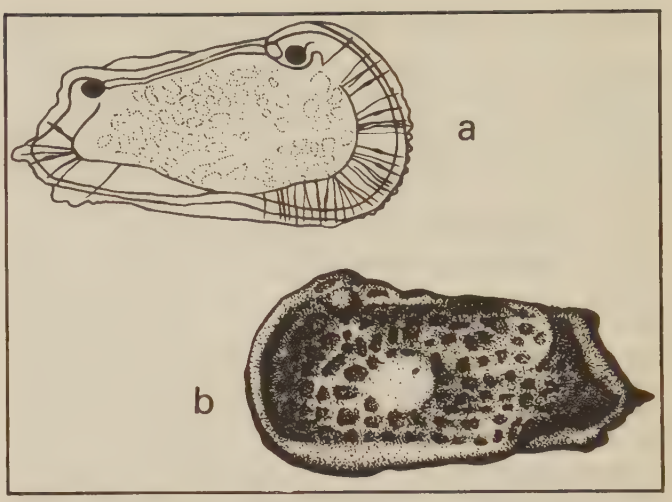


FIG. 30. *Hermanites andrewsi* n.sp. Holotype (N .Z. Geological Survey Cat. No. TO 1033): a, internal view of left valve, x 75; b, external view of left valve, x 75.

DISTRIBUTION: Occurs throughout the study area, but extremely rare at depths shallower than 37 m. Thanatocoenosis depth range: 30–200 m. Substrate: gravelly muddy sand, gravelly sand, muddy sandy gravel (thanatocoenosis.)

Subfamily UROCYTHEREIDINAE Hartmann & Puri, 1974

Genus AMBOSTRACON Hazel, 1962

TYPE SPECIES: *Ambostracon costatum* Hazel, 1962

Ambostracon cf. **A. pumila** (Brady) (Fig. 32)

1866 *Cythere pumila* Brady, *Trans. zool. Soc. Lond. 5(5)*: 378, pl. 60, figs 7a–d.

1967 *'Ambostracon' pumila* (Brady). McKenzie, *Proc. R. Soc. Vict. 80(1)*: 93, pl. 12, fig. 8; text-figs 4b, 5i.

DESCRIPTION: Carapace small to medium, thick subrectangular. Dorsal margin sinuous, ventral margin slightly incurved. Anterior broadly rounded, slightly depressed ventrally. Caudal process below mid-posterior, blunt but pronounced. Carapace ornamented with a series of ridges and reticulations. Dominated by two ridges extending from the posterior portions of the dorsal and ventral margins, merging slightly forward of the mid-posterior and extending to the median area of the carapace. Minor ridges occur marginally, anteriorly, and as secondary ridges. Duplicature of moderate width throughout. Approximately 65 marginal pore canals: straight, a few branched, concentrated anteriorly. Hingement typical for the genus.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.52 mm; height 0.27 mm; width (right valve) 0.09 mm.

DISTRIBUTION: Restricted to the innermost portion of the shelf. Living specimens occurred in one sample only, Mu 69-43 at a depth of 19 m. Thanatocoenosis depth range: 0–25 m. Substrate: sand, muddy sand (thanatocoenosis).

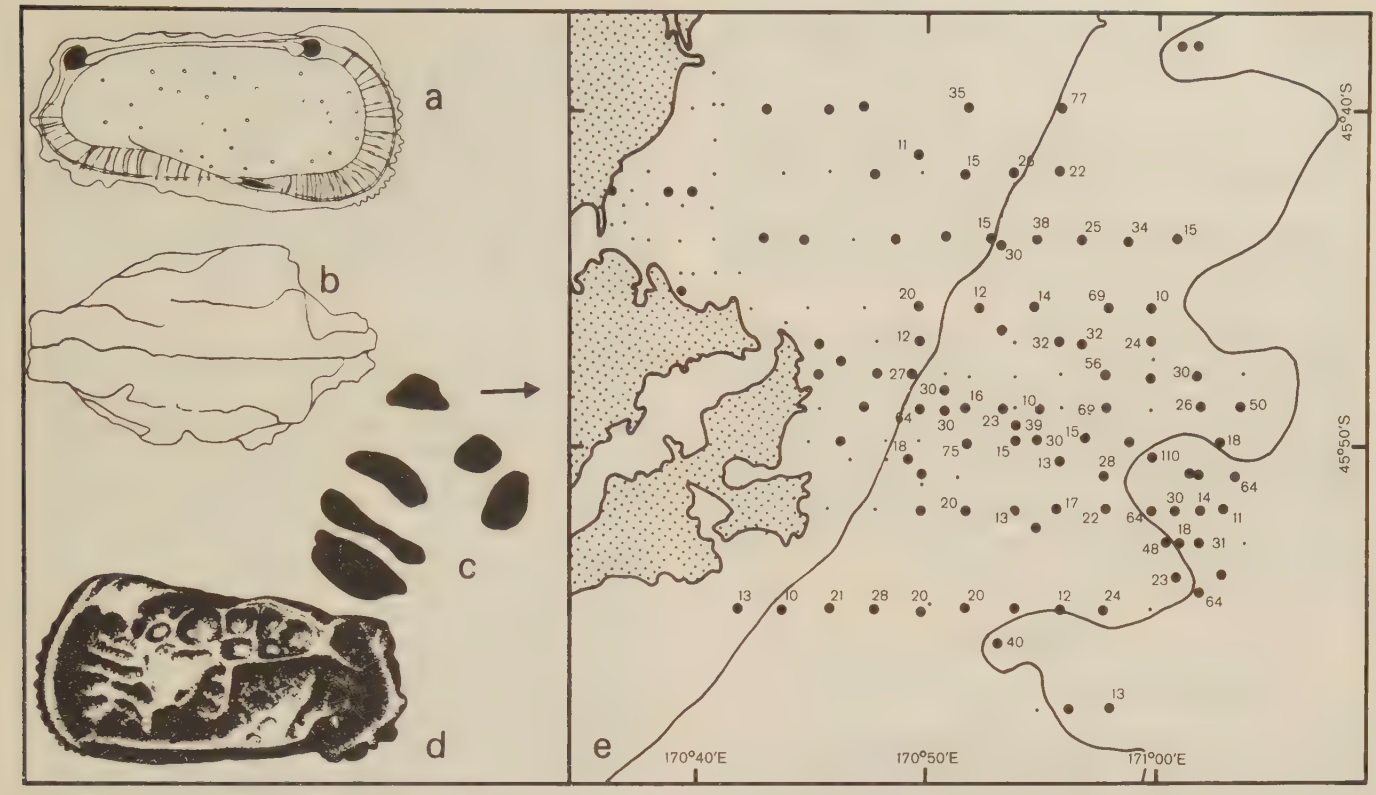


FIG. 31. *Hermanites briggsi* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1030): a, internal view of left valve, x 60; b, dorsal view of entire carapace, x 60; c, muscle scars, x 200; d, external view of left valve, x 60; e, geographic distribution.

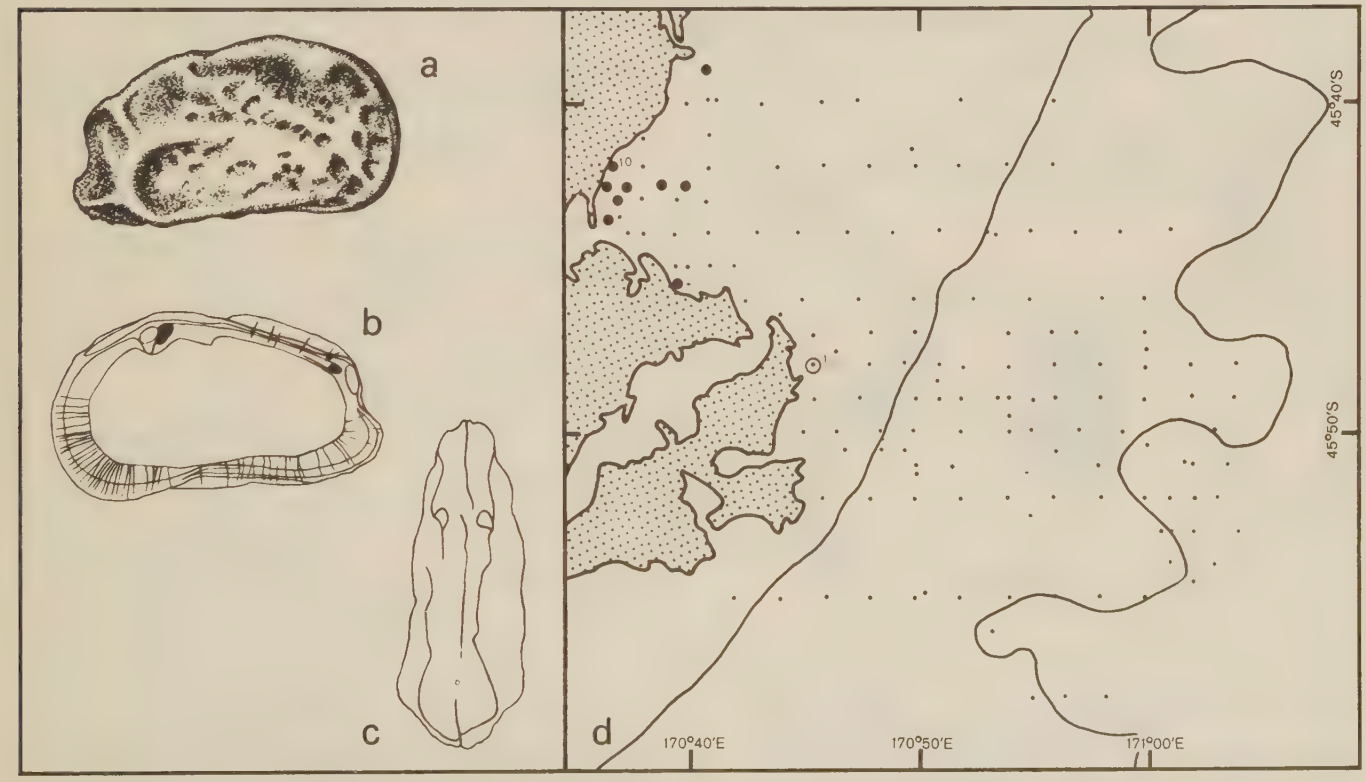


FIG. 32. *Ambostracon* cf. *A. pumila* (Brady) (N.Z. Geological Survey Cat. No. OP 1049): a, external view of right valve, x 60; b, internal view of right valve, x 60; c, dorsal view of entire (female?) carapace, x 60; d, geographic distribution.

REMARKS: The Australian specimens appear more heavily reticulated than the New Zealand forms.

Genus WAIPARACYTHEREIS Swanson, 1969

TYPE SPECIES: *Waiparacythereis joanae* Swanson, 1969

Waiparacythereis joanae Swanson (Fig. 33)

1969 *Waiparacythereis joanae* Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)*: 41, pl. 2, figs 36–8.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.75 mm; height 0.34 mm; width (entire carapace) 0.38 mm.

DISTRIBUTION: Originally described from Lower Miocene sediments of the Middle Waipara district of New Zealand. In the study area: common to abundant in inner shelf samples (0–50 m). Rare in outermost shelf and canyon samples (100–500 m). Biocoenosis depth range: 0–28 m. Thanatocoenosis depth range: 0–65 m. Substrate: sand, muddy sand ?(biocoenosis).

Genus JACOBELLA n.gen.

TYPE SPECIES: *Jacobella papanuiensis* n.sp.

DESCRIPTION: A hemicytherinid genus characterised by a moderately large, subquadrate–elongate, alate carapace. Ornamentation on the type species consists of extremely faint reticulations with concentrations of fine puncta in each reticulation. Heavier reticulations occur anteriorly, ventrally, and posteriorly. Broad caudal process developed posteroventrally. Hinge (right valve), consisting of a strong, simple anterior tooth. Anteromedian hinge element a deep 'tear drop' shaped socket. Median hinge element thin, possibly crenulate. Posterior tooth strong, highest posteriorly; 30–40 marginal pore canals, some branched, others with median thickenings. Muscle scars: a semicircle of four adductor scars. The ventral frontal scar is most commonly two fused scars. Dorsal scars are also present.

Jacobella papanuiensis n.sp. (Fig. 34)

DESCRIPTION: Carapace elongate, rectangular. Anterior broadly rounded. Caudal processes weakly developed, depressed ventrally. Carapace almost smooth, faint reticulations with puncta apparent with transmitted light, large weak reticulations may be present particularly anteriorly and ventrally. Selvage peripheral. Duplicature wide anteriorly and posteriorly. Vestibules absent. Marginal pore canals few, straight, some branched and/or thickened medially. Hingement (right valve): anterior and posterior teeth strong and simple. Median groove with a strongly developed socket anteriorly. Muscle scars: a group of four adductor scars forming a semicircle, dorsomedian scar sometimes divided with two frontal scars directly in front. Dorsal scars also present (Fig. 34d) between which, and extending from but not connected to the hingement, occurs a calcareous 'post like' structure, here considered analagous to the 'dorsal supporting scar platform' described by Williams (1966). Ocular sinuses present below and slightly in front of the

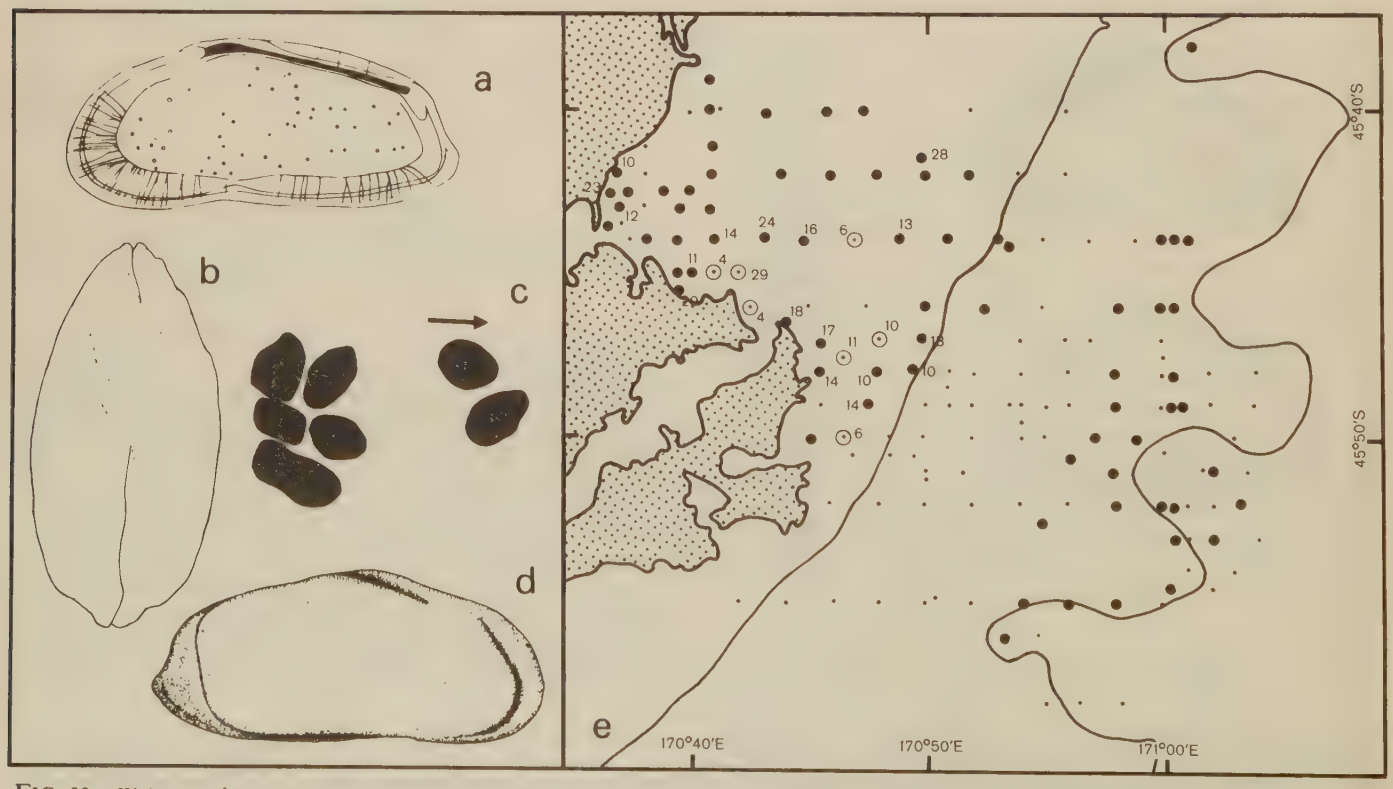


FIG. 33. *Waiparacythereis joanae* Swanson (N.Z. Geological Survey Cat. No. OP 1050): a, internal view of right valve, x 60; b, dorsal view of entire (female ?) carapace, x 60; c, muscle scars, x 200; d,,external view of right valve, x 60; e, geographic distribution.

anterior hinge elements. Dorsal view: carapace considerably inflated posteriorly.

TYPES: N.Z. Geological Survey Cat. No. TO 1029. Holotype and ten paratypes. Mu 68-24, 520 m.

DIMENSIONS OF HOLOTYPE: Length 0.52 mm; height 0.25 mm; width (right valve) 0.14 mm.

DISTRIBUTION: Rare in mid-shelf and outer shelf samples (50–150 m), common in canyon samples (150–500 m).

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948

Tribe TRACHYLEBERIDINI Sylvester-Bradley, 1948

Genus TRACHYLEBERIS Brady, 1898

TYPE SPECIES: *Cythere scabrocuneata* Brady, 1880

Trachyleberis lytteltonensis Harding & Sylvester-Bradley (Fig. 35a–c)

Not 1880 *Cythere scabrocuneata* Brady, *Rep. scient. Results explor. Voyage Challenger 1(3)* : 103, pl. 17, figs 5a–d; pl. 23, figs 2a c.

1898 *Trachyleberis scabrocuneata* (Brady). Brady, *Trans. zool. Soc. Lond. 14* : 444, pl. 47, figs 1–7, 18–25.

1952 *Trachyleberis scabrocuneata* (Brady). Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 32, pl. 3, figs 38, 39, 48.

1953 *Trachyleberis lytteltonensis* Harding and Sylvester-Bradley, *Bull. Br. Mus. nat. Hist. 2(1)* : 4, text-figs 2–19; pl. 1, figs 1–4, 7; pl. 2, figs 1–4, 7, 8.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.66 mm; height 0.37 mm; width (entire carapace) 0.33 m.

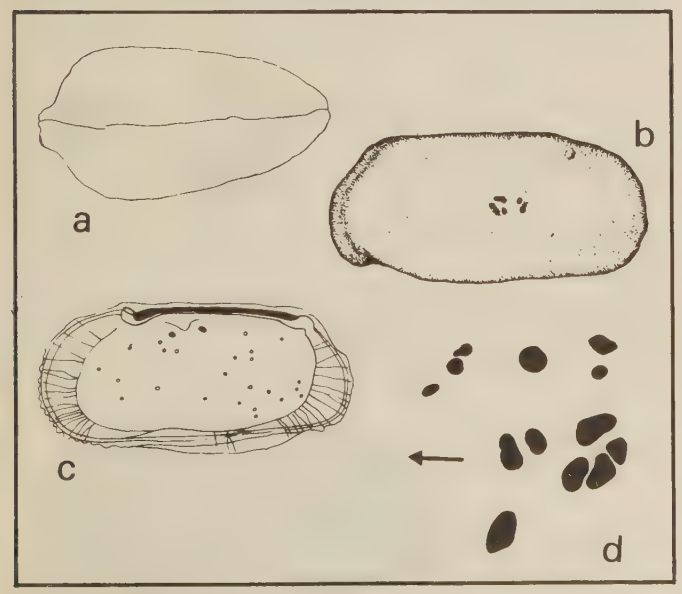


FIG. 34. *Jacobella papanuiensis* n.gen. n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1029): a, dorsal view of entire carapace, x 60; b, external view of right valve, x 60; c, internal view of right valve, x 60; d, muscle scars, x 200.

DISTRIBUTION: Hornibrook (1952) found this species at four stations in New Zealand waters. Harding and Sylvester-Bradley (1953) reported living specimens from two localities in New Zealand, at depths of 2–10 m (1–5 fm) in Lyttelton Harbour and in the seas off New Zealand at depths of 50–122 m (28–67 fm). In the study area: extremely rare on the shelf (0–250 m), rare to common in canyon samples (150–500 m).

Trachyleberis thomsoni? Hornibrook (Fig. 35d, e)

1926 *Cythere scutigera* (Brady) Chapman *N.Z. geol. Surv. Paleont. Bull. 11* : 103, pl. 22, fig. 1.

1952 *Trachyleberis thomsoni* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 33, pl. 3, figs 40, 41, 47.

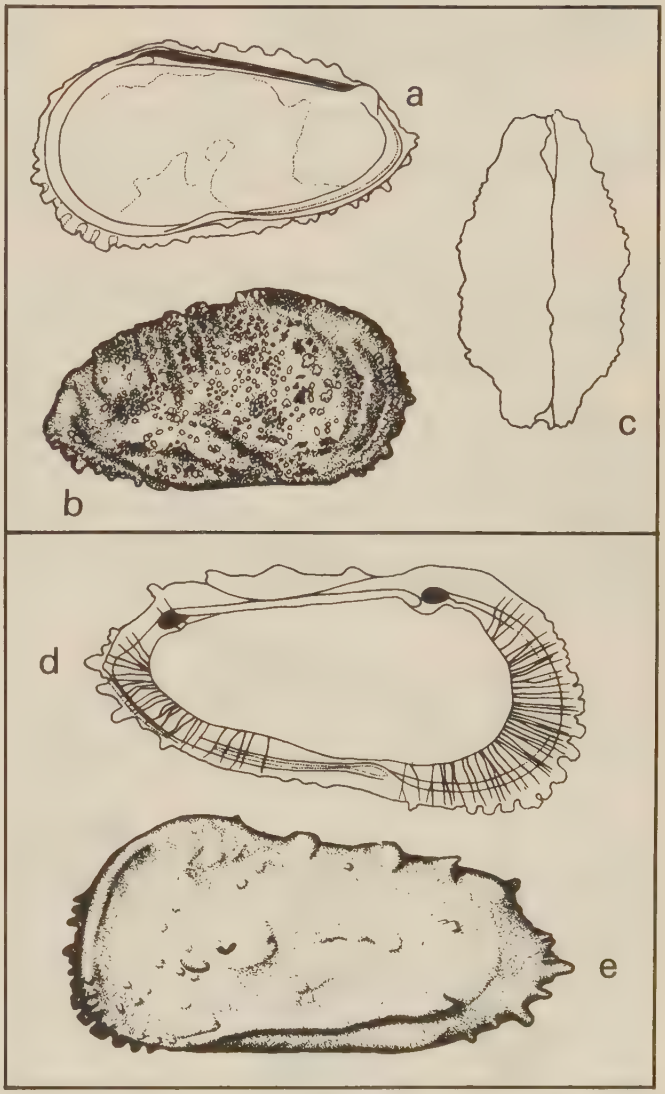


FIG. 35. *Trachyleberis lytteltonensis* Harding & Sylvester-Bradley. (N.Z. Geological Survey Cat. No. OP 1053): a, internal view of immature right valve, x 75; b, external view of immature right valve, x 75; c, dorsal view of entire carapace, x 75.
Trachyleberis thomsoni? Hornibrook (N.Z. Geological Survey Cat. No. OP 1054): d, internal view of left valve, x 75; e, external view of left valve, x 75.

Not 1953 *Trachyleberis* (?) *thomsoni* (Howe & Law). Puri, *Am. Midl. Nat. 49(1)* : 176, pl. 1, figs 6–8.

1969 *Trachyleberis thomsoni* Hornibrook. Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)* : 43, pl. 4, figs 51–3.

DIMENSIONS OF FIGURED SPECIMEN: (juvenile). Length 0.86 mm; height 0.43 mm; width (left valve) 0.19 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. In the study area: recorded rarely on the outer shelf (50–150 m) and in canyon samples (150–500 m).

REMARKS: All recovered specimens were juveniles. Consequently this determination must be considered as rather tentative.

Tribe VEENIINI Puri, 1973

Genus CYTHEREIS Jones, 1849

TYPE SPECIES: *Cytherina ciliata* Reuss, 1846

'Cythereis' planalta Hornibrook. (Fig. 36)

1952 *Cythereis planalta* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 37, pl. 5, figs 70, 71, 77

DIMENSIONS OF FIGURED SPECIMEN: Length 0.93 mm; height 0.51 mm; width (right valve) 0.23 mm.

FIG. 36. *'Cythereis' planalta* Hornibrook (N.Z. Geological Survey Cat. No. OP 1055): a, internal view of right valve, x 75; b, external view of right valve, x 75; c, muscle scars, x 200.

DISTRIBUTION: Occurs in six samples only: Mu 67-142, 750 m; Mu 68-24, 520 m; Mu 68-27, 630 m; Mu 68-29, 580 m; Mu 68-84, 660 m; Mu 68-86, 182 m.

REMARKS: *Cythereis* (sensu stricto) as suggested by many authors, is restricted to the Cretaceous. The author has provisionally placed *'C.' planalta* and *'C.' incerta* n.sp. in this group until examination of soft parts enable more complete generic descriptions to be made.

'Cythereis' incerta n.sp. (Fig. 37)

DESCRIPTION: Carapace subquadrate to subrhomboidal. Dorsal and ventral margins subparallel; dorsal margin concave, ventral margin slightly convex. Anterior margin broadly rounded, depressed ventrally. Posterior acutely angled from the ventral margin. Posterior ornamented with approximately six large spines, anterior serrate along the ventral half. Carapace ornamented with deep, irregular reticulations with weak ridges. Ridge along the ventrolateral keel strongly developed; a weak median ridge extends posteriorly from the subcentral tubercle. Subcentral tubercle weakly developed. Eye spots clearly present. Interior: duplicature of moderate width throughout. Line of concrescence and inner margin coincide throughout. Marginal pores straight and simple, a few branched. Hingement strong. Right valve: posterior and anterior teeth simple, extremely large.

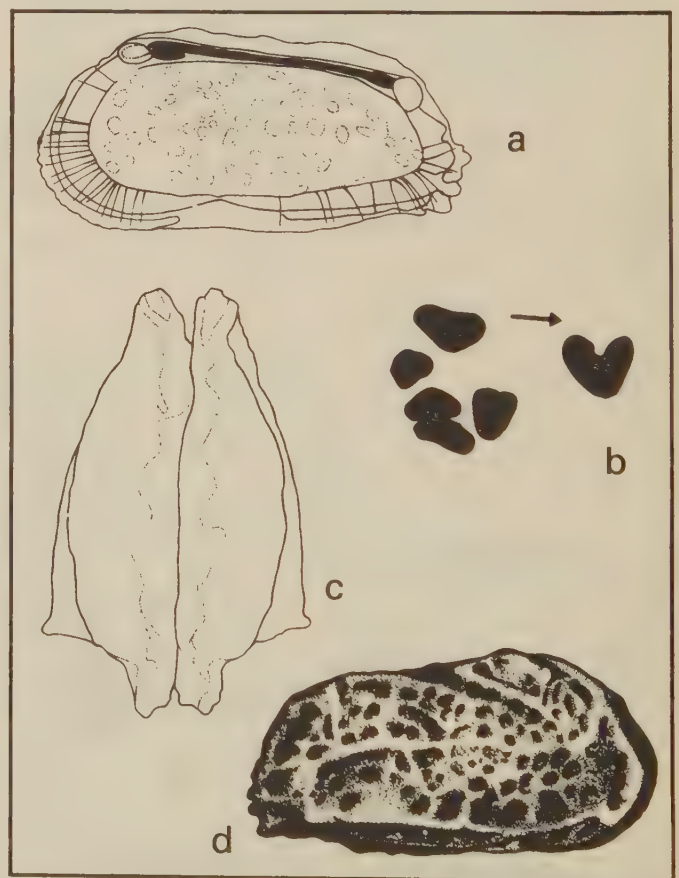


FIG. 37. *'Cythereis' incerta* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1032): a, internal view of right valve, x 60; b, muscle scars, x 200; c, dorsal view of entire carapace, x 60; d, external view of right valve, x 60.

TYPES: N.Z. Geological Survey Cat. No. TO 1032. Holotype and 12 paratypes. Mu 67-80, 168 m.

DIMENSIONS OF HOLOTYPE: Length 0.74 mm; height 0.37 mm; width (right valve) 0.21 mm.

DISTRIBUTION: Rare on the inner and middle shelf (0–75 m), common to abundant in outer shelf and canyon samples (75–500 m). Thanatocoenosis depth range: 75–?170 m. Substrate: gravelly sand, sandy gravel (thanatocoenosis).

REMARKS: Characterised by a thick, reticulate carapace with weakly developed median and ventrolateral ridges.

Tribe COSTAINI Hartmann & Puri, 1974

Genus PONTICOCYTHEREIS McKenzie, 1967

TYPE SPECIES: *Cythereis militaris* Brady, 1866

Ponticocythereis decora n.sp. (Fig. 38)

DESCRIPTION: Carapace medium to large, subquadrate. Dorsal margin straight, upcurved from the anterior third, posteriorly. Anterior broadly rounded, posterior strongly upturned. Posterodorsal angle almost a right angle. Carapace ornamented with four distinct rows of serrations. A marginal row extending from just below the anterodorsal angle around the periphery of the carapace, terminating at the posterodorsal angle. A second row begins in a similar position to that described above, but at a higher level. This ridge continues parallel to the marginal ridge until, at approximately one-third along the ventral margin, it begins to swing sharply upwards terminating at a point about two-thirds along the length of the ventral margin. At about one-third of the carapace height above this second ridge another shorter ridge runs subparallel to the ventral margin. A short, less prominent ridge runs along the dorsal margin. A low rounded ridge extends from the prominent eye spot dorsally for approximately half the carapace height.

TYPES: N.Z. Geological Survey Cat. No. TO 1031. Holotype and three paratypes, Mu 69-47, 116 m.

DIMENSIONS OF HOLOTYPE: Length 0.65 mm; height 0.41 mm; width (left valve) 0.16 mm.

DISTRIBUTION: Occurs extremely rarely on the mid-shelf and outer shelf (50–150 m).

REMARKS: Close affinities to *Trachyleberis probesoides* Hornibrook, 1952; however, *Ponticocythereis decora* lacks the diagonal rib joining the dorsal crest. Also similar to *T. tricristata* (Brady, 1880).

Family NEOCYTHERIDEIDIDAE Puri, 1957

Genus COPYTUS Skogsberg, 1939

TYPE SPECIES: *Copytus caligula* Skogsberg, 1939

Copytus novaezealandiae (Brady) (Fig. 39)

1898 *Cytherideis novaezealandiae* Brady, *Trans. zool. Soc. Lond. 14*: 446, text-figs 1–4.

1967 *Copytus rara* McKenzie, *Proc. R. Soc. Vict. 80(1)*: 71, fig. 2j.

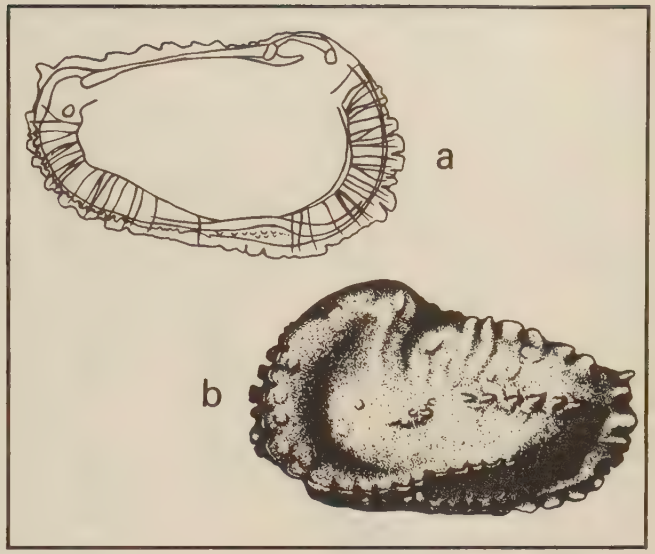


FIG. 38. *Ponticocythereis decora* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1031): a, internal view of left valve, x 75; b, external view of left valve, x 75.

1969 *Copytus rara* McKenzie. Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)*: 45, pl. 5, figs 69–71.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.87 mm; height 0.28 mm; width (left valve) 0.15 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters and McKenzie (1967) described it as *Copytus rara* from the Recent of south-eastern Australia. In the study area: common in inner shelf samples (0–50 m), extremely rare in outer shelf and canyon samples (50–500 m). Biocoenosis depth range: 0–65 m. Thanatocoenosis depth range: 0–65 m. Substrate: sand, muddy sand, gravelly sand (biocoenosis).

Family CUSHMANIDEIDAE Puri, 1973

Genus PARAKRITHE van den Bold, 1958

TYPE SPECIES: *Cytheridea (Dolocytheridea) vermunti* van den Bold, 1946

Parakrithe sp. (Fig. 40)

DESCRIPTION: Carapace of medium size, elongate and smooth. Dorsal and ventral margins parallel. Dorsal margin straight, ventral margin slightly concave. Anterior broadly rounded, posterior obliquely truncated. Duplicature irregular, extremely wide anteriorly, moderately wide ventrally. Vestibule weakly developed anteriorly, absent ventrally and posteriorly. Marginal pore canals few, long, concentrated anteriorly, some branched and/or swollen medially. Hingement typical for the genus. Muscle scars: a vertical row of four adductor scars with a single mandibular below and slightly in front. Two frontal scars present, comprising a larger elongated scar with a smaller circular scar below.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.53 mm; height 0.24 mm; width (left valve) 0.15 mm.

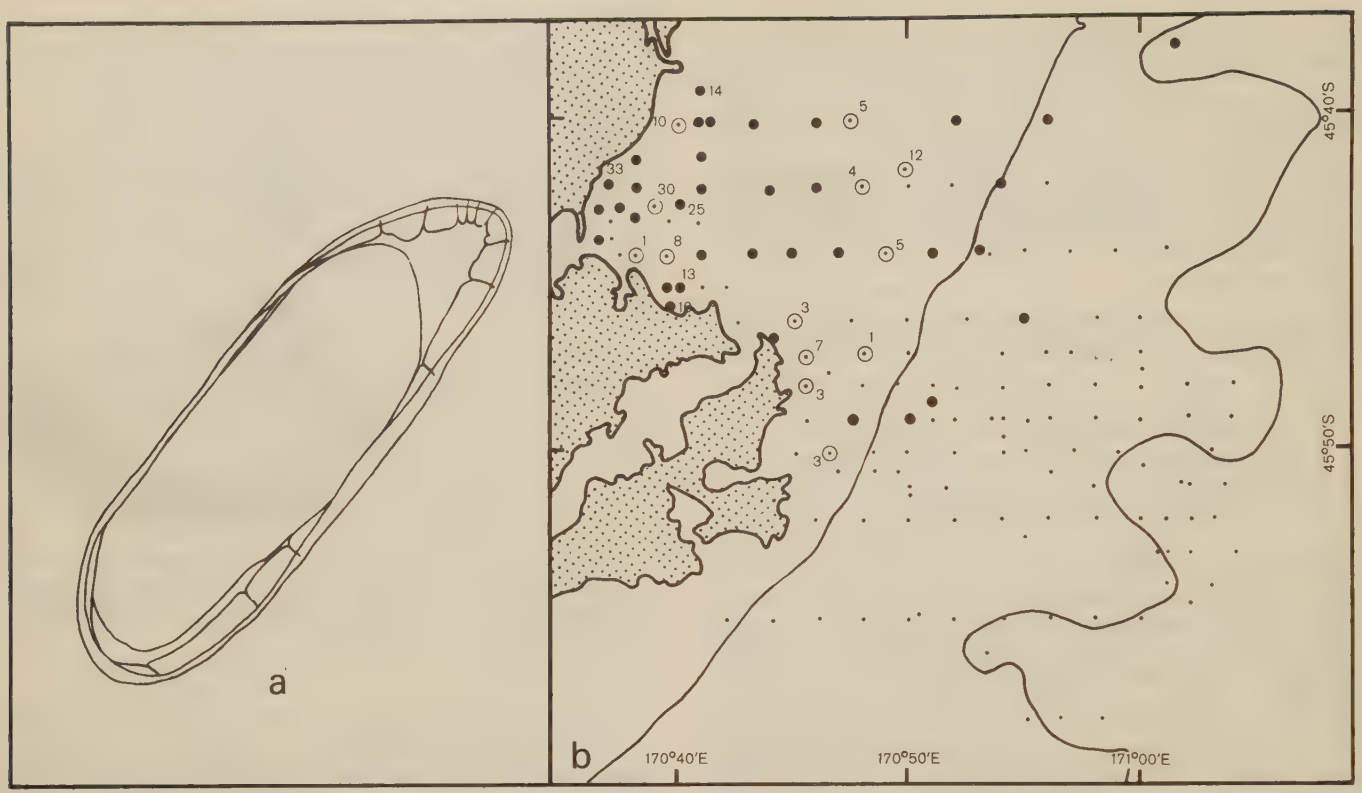


FIG. 39. *Copytus novaezealandiae* (Brady) (N.Z. Geological Survey Cat. No. OP 1056): a, internal view of left valve, x 75; b, geographic distribution.

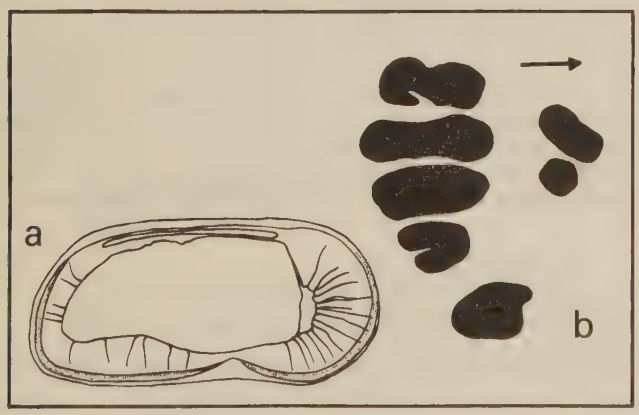


FIG. 40. *Parakrithe* sp. (N.Z. Geological Survey Cat. No. OP 1058): a, internal view of left valve, x 75; b, muscle scars, x 200.

DISTRIBUTION: Occurs in three samples only: Mu 67-142, 375 m; Mu 68-84, 400 m; Mu 69-18, 45 m.

Genus PONTOCYTHERE Dubowsky, 1939

TYPE SPECIES: *Pontocythere tchernjawskii* Dubowsky, 1939

Pontocythere hedleyi (Chapman) (Fig. 41)

1906 *Cytherideis hedleyi* Chapman, *Trans. N.Z. Inst. 38*: 110, pl. 3, figs 8a-c.

DESCRIPTION: Carapace elongate. Dorsal and ventral margins subparallel. Dorsal margin slightly arched, ventral margin slightly incurved medially. Anterior broadly rounded, depressed ventrally; posterior evenly rounded. Carapace ornamented with rectangular groupings of punctations, each group being separated by a weak ridge. Selvage strong, particularly anterodorsally, subperipheral. Duplicature wide anteriorly. Vestibule well developed anteriorly. 25–30 marginal pore canals, simple, many with median and/or terminal thickenings. Normal pores small and numerous. Hingement: anterior elements of pontocytherinid form but posteriorly in the left valve, the median bar is absent, replaced by a groove. A small weak posterior tooth is also present.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.60 mm; height 0.26 mm; width (right valve) 0.17 mm.

DISTRIBUTION: Occurs throughout the study area. Biocoenosis depth range: 0–25 m. Thanatocoenosis depth range: 65–130 m. Substrate: sand (biocoenosis).

REMARKS: Easily distinguished from other pontocytherinids of similar form by its rather peculiar hingement.

Family EUCYTHERIDAE Puri, 1954

Genus EUCYTHERE Brady, 1868

TYPE SPECIES: *Cythere declivis* Norman, 1865

Subgenus ROTUNDRACYTHERE Mandelstam (in Abushik *et al.*), 1958

TYPE SPECIES: *Euthere rotunda* Hornibrook, 1952

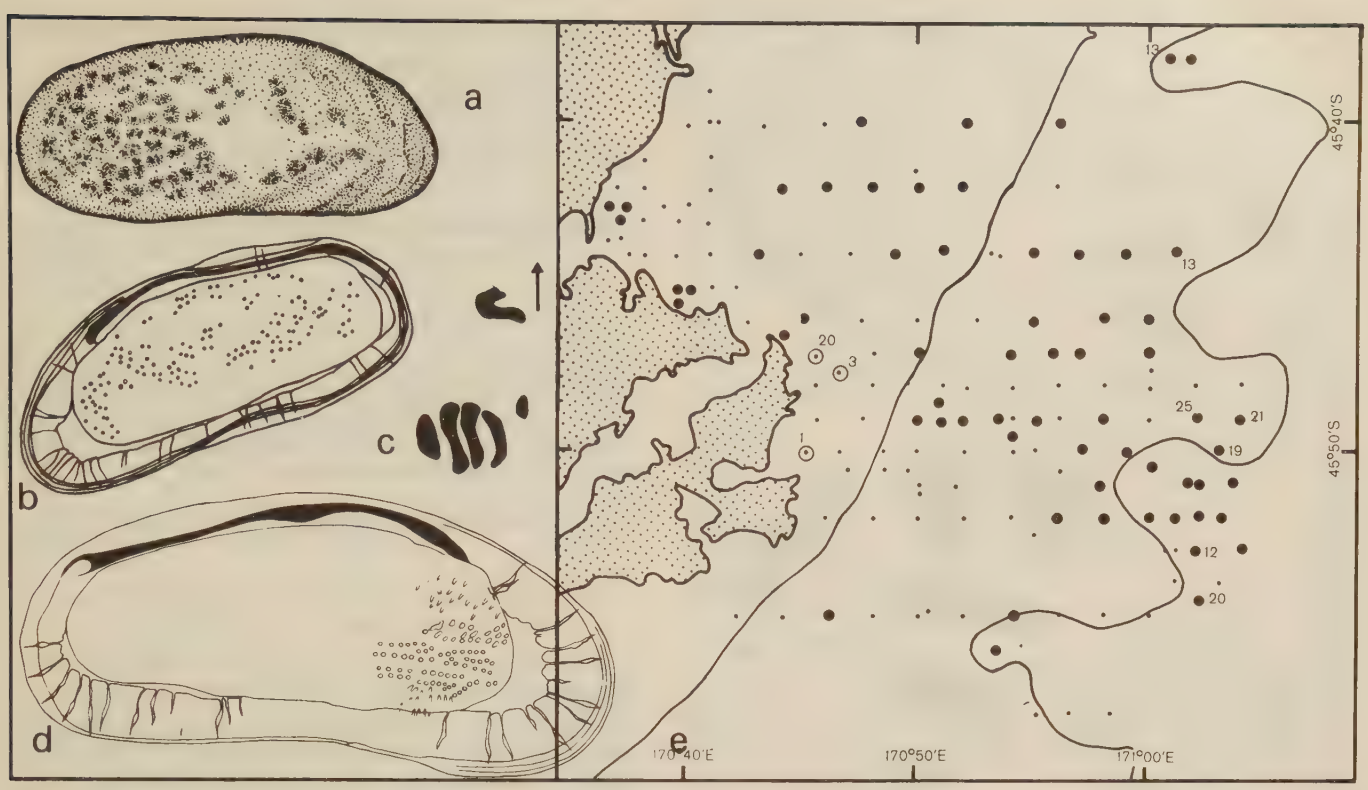


FIG. 41. *Pontocythere hedleyi* (Chapman) (N.Z. Geological Survey Cat. No. OP 1041): a, external view of right valve, x 75; b, internal view of right valve, x 75; c, muscle scars, x 200; d, internal view of left valve, x 100; e, geographic distribution.

Eucythere (Rotundracythere) gravepuncta? Hornibrook (Fig. 42)

1952 *Eucythere gravepuncta* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 29, pl. 1, figs 10–12, 18.

1958 *Rotunracythere gravepuncta* (Hornibrook). Mandelstam, *in* Abushik *et al. Microfauna CCP. 9* : 281.

1969 *Eucythere* (*Rotundracythere*) *gravepuncta* Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)* : 45, pl. 5, figs 77–79.

DESCRIPTION: Marginal pore canals few, anteriorly most branched either medially or near the outer margin.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.42 mm; height 0.25 mm; width (right valve) 0.12 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. It was found throughout the study area. Extremely rare in mid-shelf samples. Common in outermost shelf samples. Thanatocoenosis depth range: 0–150 m. Substrate: sand, muddy sand, gravelly sand, gravelly muddy sand (thanatocoenosis).

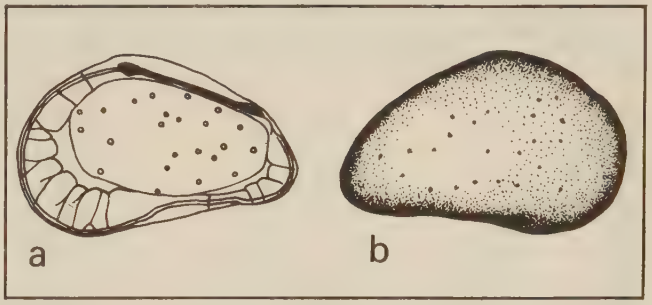


FIG. 42. *Eucythere (Rotundracythere) gravepuncta*? Hornibrook (N.Z. Geological Survey Cat. No. OP 1057): a, internal view of right valve, x 75; b, external view of right valve, x 75.

Family KRITHIDAE Mandelstam, 1958

Genus KRITHE Brady, Crosskey & Robertson, 1874

TYPE SPECIES: *Cythere* (*Cytherideis*) *bartonensis* Jones, 1857

Krithe sp. (Fig. 43)

DESCRIPTION: Carapace large, smooth, and elongate. Dorsal and ventral margins straight and parallel. Anterior broadly rounded. Posterior rounded dorsally, squarely truncated at posteroventral angle, prominent posterior indentation. Duplicature widest posteriorly, wide in the posterior half of the ventral margin, strongly indented mid-ventrally. Anterior vestibule extremely large, absent ventrally. Marginal pore canals few and short, some thickened and/or medially curved. Hinge-ment typical for genus. Muscle scars: a vertical row of four adductor scars (dorsal-most scar cleaved) and frontal scar(s) of rather unusual W-form.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.98 mm; height 0.48 mm; width (left valve) 0.28 mm.

DISTRIBUTION: Occurs in five samples only: Mu 67-53, 321 m; Mu 67-140, 63 m; Mu 67-142, 375 m; Mu 69-53, 22 m; Mu 69-54, 13 m.

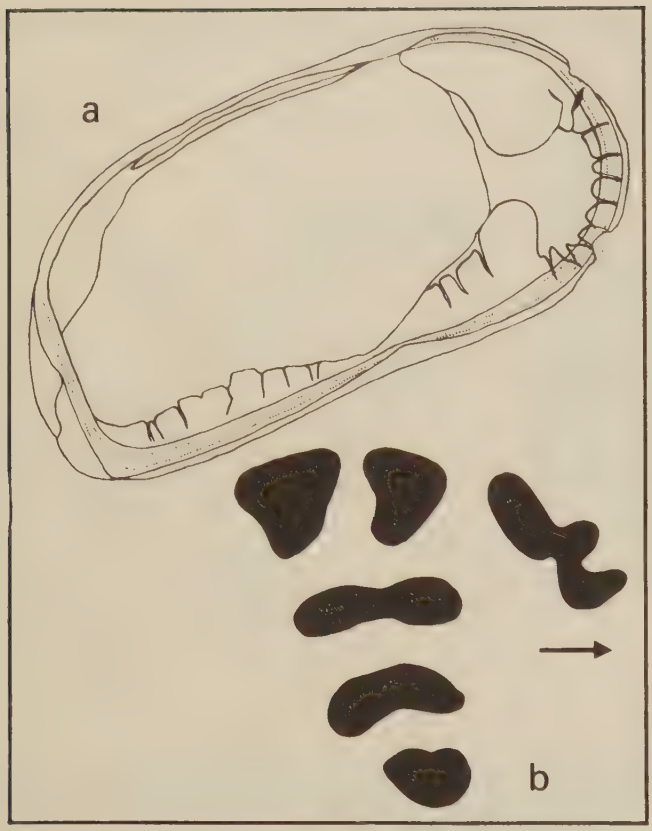


FIG. 43. *Krithe* sp. (N.Z. Geological Survey Cat. No. OP 1074): a, internal view of left valve, x 75; b, muscle scars, x 200.

Family CYTHERURIDAE G.W. Mueller, 1894

Subfamily CYTHEROPTERINAE Hanai, 1957

Genus OCULOCYTHEROPTERON Bate, 1972

TYPE SPECIES: *Oculocytheropteron praenuntatum* Bate, 1972

Oculocytheropteron acutangulum (Hornibrook) (Fig. 44)

1952 *Cytheropteron* (*Cytheropteron*) *acutangulum* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 55, pl. 12, figs 166–8.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. Found throughout the study area. Thanatocoenosis depth range: 40–100 m. Substrate: gravelly muddy sand, muddy sand, muddy sandy gravel (thanatocoenosis).

Oculocytheropteron confusum (Hornibrook) (Fig. 45a–c)

1952 *Cytheropteron* (*Cytheropteron*) *confusum* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 55, pl. 12, figs 172–4.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.47 mm; height 0.30 mm; width (left valve) 0.16 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. In the study area: rare in inner shelf (0–50 m) and canyon samples (150–500 m).

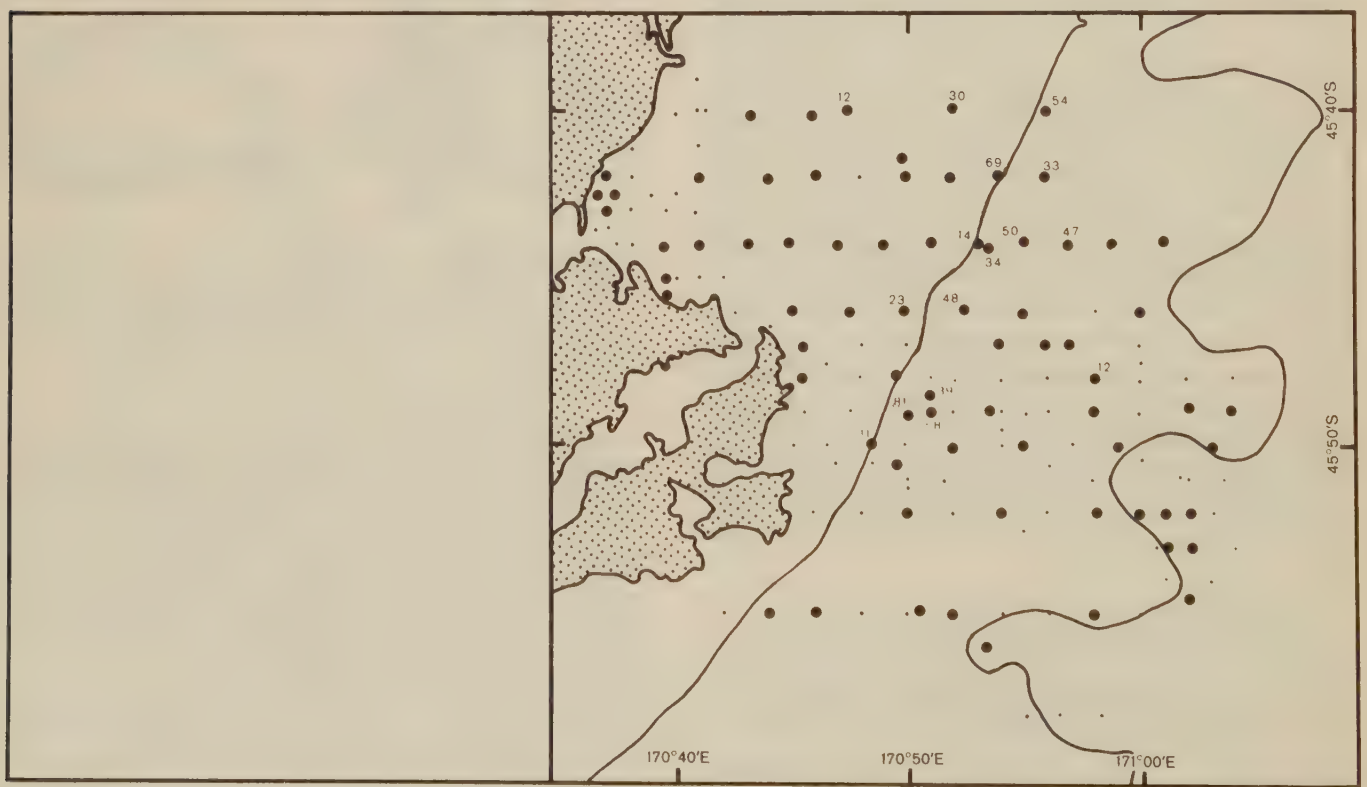


FIG. 44. *Oculocytheropteron acutangulum* (Hornibrook): geographic distribution.

Oculocytheropteron dividentum (Hornibrook)
(Fig. 45d, e)

1952 *Cytheropteron* (*Cytheropteron*) *dividentum* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 57, pl. 13, figs 184–8.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.33 mm; height 0.22 mm; width (right valve) 0.11 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. Found rarely throughout the study area.

Oculocytheropteron fornix (Hornibrook) (Fig. 46)

1952 *Cytheropteron* (*Cytheropteron*) *fornix* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 54, pl. 11, figs 159–61.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.43 mm; height 0.31 mm; width (right valve) 0.13 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters.

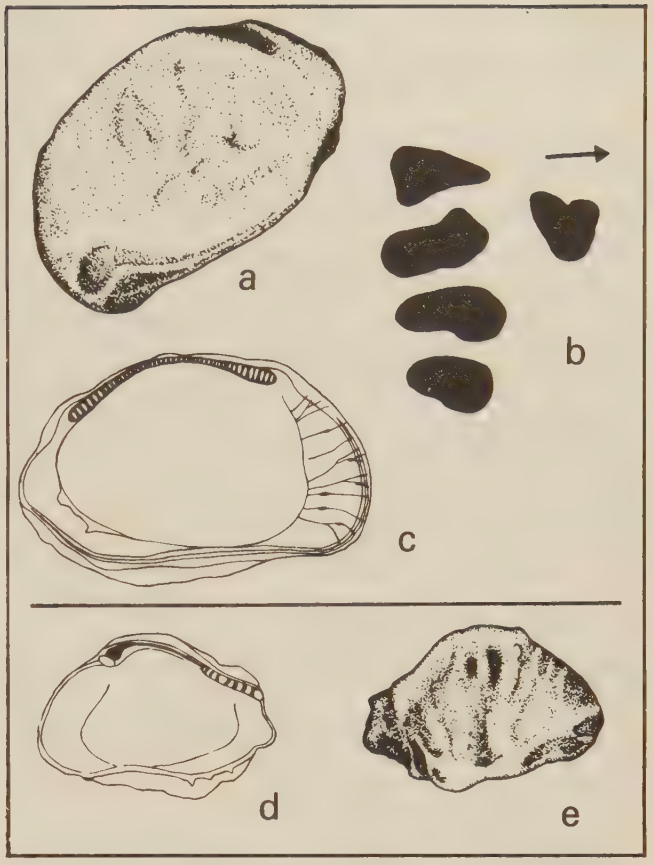


FIG. 45. *Oculocytheropteron confusum* (Hornibrook) (N.Z. Geological Survey Cat. No. OP 1064): a, external view of left valve, x 100; b, muscle scars, x 200; c, internal view of left valve, x 100. *Oculocytheropteron dividentum* (Hornibrook) (N.Z. Geological Survey Cat. No. OP 1065): d, internal view of right valve, x 100; e, external view of right valve, x 100.

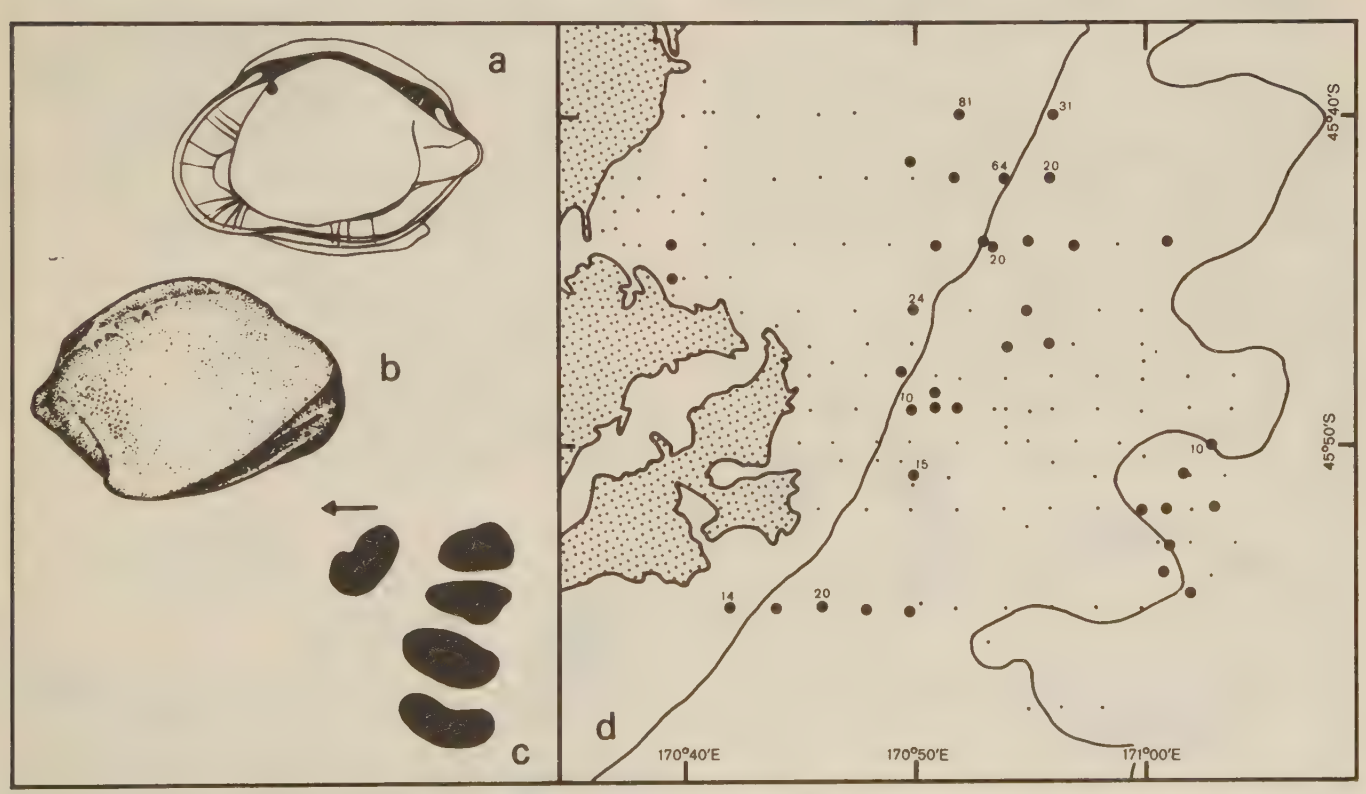


FIG. 46. *Oculocytheropteron fornix* (Hornibrook) (N.Z. Geological Survey Cat. No. OP 1066): a, internal view of right valve, x 100; b, external view of right valve, x 100; c, muscle scars, x 200; d, geographic distribution.

Oculocytheropteron mosaica (Swanson) (Fig. 47)

1969 *Cytheropteron mosaica* Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)* : 46, pl. 6, figs 90–2.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.45 mm; height 0.28 mm; width (left valve) 0.13 mm.

Oculocytheropteron vertex (Hornibrook)

1952 *Cytheropteron (Cytheropteron) vertex* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 56, pl. 12, figs 177, 179, 180.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. In the study area: common on the outer shelf (50–150 m), rare in inner shelf (0–50 m) and canyon samples (150–500 m). Thanatocoenosis depth range: 0–90 m. Substrate: muddy sand, gravelly muddy sand, sandy gravel (thanatocoenosis).

Genus CYTHEROPTERON Sars, 1866

Subgenus CYTHEROPTERON Sars, 1866

TYPE SPECIES: *Cythere latissima* Norman, 1865

Cytheropteron (Cytheropteron) wellmani Hornibrook (Fig. 48)

1952 *Cytheropteron (Cytheropteron) wellmani* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 53, pl. 11, figs 154–6.

1969 *Cytheropteron wellmani* Hornibrook. Swanson, *Trans. R. Soc. N.Z., Earth Sci. 7(3)* : 46, pl. 6, figs 88–9.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.42 mm; height 0.26 mm; width (left valve). 0.09 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. In the study area: rare on the outermost shelf (100–150 m), common in canyons (150–500 m). Thanatocoenosis depth range: 175–400 m. Substrate: gravelly sand, gravelly muddy sand, muddy sand (thanatocoenosis).

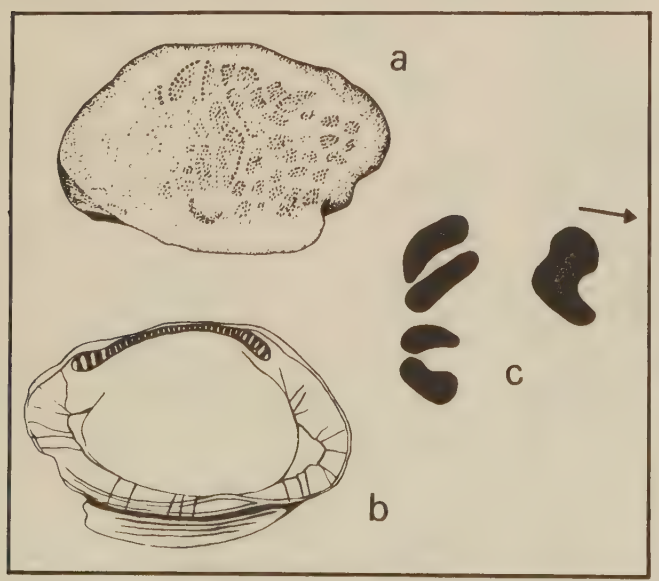


FIG. 47. *Oculocytheropteron mosaica* (Swanson) (N.Z. Geological Survey Cat. No. OP 1067): a, external view of left valve, x 100; b, internal view of left valve, x 100; c, muscle scars, x 200.

Subfamily CYTHERURINAE G.W. Mueller, 1894

Genus SEMICYTHERURA Wagner, 1957

TYPE SPECIES: *Cythere nigrescens* Baird, 1838

Semicytherura arteria n.sp. (Fig. 49a, b)

Not 1880 *Cytherura costellata* Brady, *Rep. scient. Results explor. Voyage Challenger 1(3)* : 134, pl. 32, figs 7a–d.

1952 *Cytherura costellata* Brady. Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 50–51, pl. 14, figs 229, 230, 233, 234.

DESCRIPTION: Carapace small, elongate, subrectangular to subrhomboidal. Anterior irregularly rounded, depressed ventrally. Caudal process well developed. Dorsal and ventral margins parallel, but ventral margin slightly sinuous. Carapace ornamented with a series of strong primary ridges connected by weaker secondary ridges. Carapace considerably flattened anteriorly. Selvage strong throughout. Duplicature wide anteriorly. Marginal pore canals few, concentrated anteriorly, generally straight and simple.

TYPES: N.Z. Geological Survey Cat. No. TO 1035. Holotype and seven paratypes. Mu 67-139, 67 m.

DIMENSIONS OF HOLOTYPE: Length 0.42 mm; height 0.19 mm; width (right valve) 0.11 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters. In the study area: rare in both inner and outer shelf samples.

REMARKS: As pointed out by Hanai (1957, p. 19) and Eagar (1971, p. 58), this species, identified by Hornibrook (1952) as *Cytherura costellata* Brady, differs considerably from Brady's (1880) original. *Semicytherura arteria* n.sp. is characterised by the strong main ridge systems and consequent deep reticulations (particularly anteriorly).

Semicytherura cf. **S. costellata** (Brady) (Fig. 49c–e)

1880 *Cytherura costellata* Brady, *Rep. scient. Results explor. Voyage Challenger 1(3)* : 134, pl. 32, figs 7a–d.

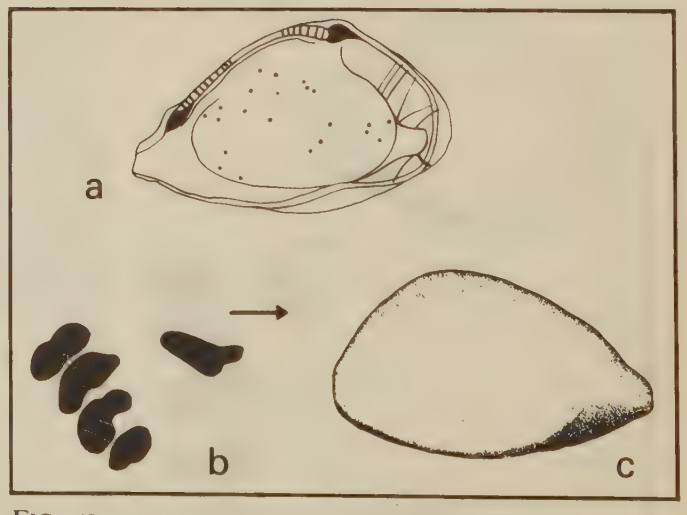


FIG. 48. *Cytheropteron (Cytheropteron) wellmani* Hornibrook (N.Z. Geological Survey Cat. No. OP 1068): a, internal view of left valve, x 100; b, muscle scars, x 200; c, external view of left valve, x 100.

Not 1952 *Cytherura costellata* Brady. Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 50–51, pl. 14, figs 229, 230, 233, 234 (=*Semicytherura arteria* n.sp.)

1964 *Semicytherura* sp. aff. *S. costellata* (Brady). Benson, *Paleont. Contr. Univ. Kans. 6* : 17, pl. 2, figs 3, 5, 6; text-fig. 10.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.40 mm; height 0.20 mm; width (entire carapace) 0.22 mm.

DISTRIBUTION: Occurs throughout the study area. Biocoenosis depth range : living specimens located in one sample only: Mu 68-20, 47 m. Thanatocoenosis depth range : 60–80 m. Substrate : gravelly muddy sand, muddy sandy gravel (thanatocoenosis).

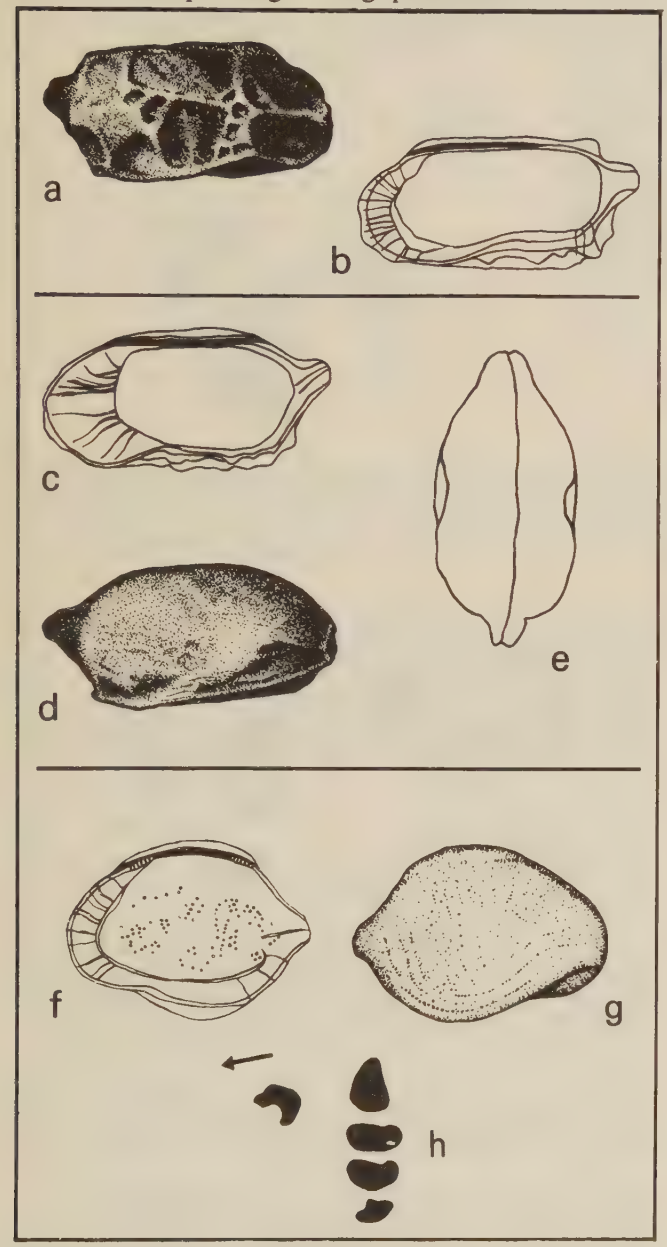


FIG. 49. *Semicytherura arteria* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1035): a, external view of right valve, x 75; b, internal view of right valve, x 75.
Semicytherura cf. *S. costellata* (Brady) (N.Z. Geological Survey Cat. No. OP 1060): c, internal view of right valve, x 100; d, external view of right valve, x 100; e, dorsal view of entire carapace, x 100.
Semicytherura sericava (Hornibrook) (N.Z. Geological Survey Cat. No. OP 1063): f, internal view of right valve, x 75; g, external view of right valve, x 75; h, muscle scars, x 200.

REMARKS: Compared with Benson's (1964) Antarctic forms, the Otago Shelf specimens have weakly developed ridge systems and caudal processes.

Semicytherura sericava (Hornibrook) (Fig. 49f–h)

1952 *Cytherura sericava* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 50, pl. 14, figs 231, 232, 241.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.38 mm; height 0.27 mm; width (right valve) 0.11mm.

DISTRIBUTION: Hornibrook (1952) recorded this species from the Aupourian and Cookian marine molluscan provinces of New Zealand. In the study area : common in inner shelf samples (0–50 m), extremely rare in outer shelf samples (50–150 m). Thanatocoenosis depth range: 0–40 m. Substrate: sandy gravel, sand, muddy sand (thanatocoenosis).

REMARKS: Hornibrook (1952) described three species of *Cytherura* (*C. hexagona, C. laticauda*, and *C. sericava*), all of which display *Cytherura*-like internal structures. In shape and external features, however, they more closely resemble the genus *Semicytherura.*

Genus HEMICYTHERURA Elofson, 1941

Subgenus HEMICYTHERURA Elofson, 1941

TYPE SPECIES: *Cythere cellulosa* Norman, 1865

Hemicytherura (Hemicytherura) gravis Hornibrook (Fig. 50a–c)

1952 *Hemicytherura gravis* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 59, pl. 13, figs 198–201, 212.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.37 mm; height 0.25 mm; width (right valve) 0.10 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand waters. Found throughout the study area. Thanatocoenosis depth range: 70–100 m. Substrate: gravelly muddy sand, gravelly sand, muddy sandy gravel (thanatocoenosis).

Hemicytherura (Hemicytherura) aucklandica Hornibrook. (Fig. 50d, e)

1952 *Hemicytherura aucklandica* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 58, pl. 14, figs 217, 224–26.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.34 mm; height 0.20 mm; width (left valve) 0.09 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species only from the subantarctic Rossian molluscan province. Found in three samples in the study area only : Mu 68-25, 480 m; Mu 68-27, 630 m; Mu 68-84, 660 m.

Subgenus KANGARINA Coryell & Fields, 1937

TYPE SPECIES: *Kangarina quellita* Coryell & Fields, 1937

FIG. 50. *Hemicytherura (Hemicytherura) gravis* Hornibrook (N.Z. Geological Survey Cat. No. OP 1062): a, internal view of right valve, x 75; b, external view of right valve, x 75; c, geographic distribution.
Hemicytherura (Hemicytherura) aucklandica Hornibrook (N.Z. Geological Survey Cat. No. OP 1059): d, external view of left valve, x 100; e, internal view of left valve, x 100.

Hemicytherura (Kangarina) radiata Hornibrook (Fig. 51)

1952 *Hemicytherura radiata* Hornibrook, *N.Z. geol. Surv. Paleont. Bull. 18* : 61, pl. 14, figs 218, 227, 228.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.31 mm; height 0.20 mm; width (left valve) 0.10 mm.

DISTRIBUTION: Hornibrook (1952) recorded this species throughout New Zealand and Subantarctic waters.

Family LOXOCONCHIDAE Sars, 1925

Genus LOXOCONCHA Sars, 1866

TYPE SPECIES: *Cythere rhomboidea* Fischer, 1855

Loxoconcha cf. **L. punctata** Thomson (Fig. 52)

1878 *Loxoconcha punctata* Thomson, *Trans. N.Z. Inst. 11* : 255, figs B. 3a–k.

DESCRIPTION: Interior: selvage strong, peripheral. Duplicature of moderate width throughout. Vestibules narrow. Approximately 15 simple marginal pore canals. Hingement and muscle scars typical for the genus.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.57 mm; height 0.38 mm; width (left valve) 0.15 mm.

DISTRIBUTION; Thomson (1878) recorded it from among seaweed in Otago Harbour. In the study area : restricted to the inner shelf (0–50 m). Biocoenosis depth range: 0–75 m. Thanatocoenosis depth range: 0–?25 m. Substrate : sand (biocoenosis).

FIG. 51. *Hemicytherura (Kangarina) radiata* Hornibrook (N.Z. Geological Survey Cat. No. OP 1061): a, external view of left valve, x 75; b, internal view of left valve, x 75; c, muscle scars, x 200.

Family PARADOXOSTOMATIDAE Brady & Norman, 1889

Genus SCLEROCHILUS Sars, 1866

TYPE SPECIES: *Cythere contorta* Norman, 1862

Sclerochilus sp.a (Fig. 53a, b)

DIMENSIONS OF FIGURED SPECIMEN: Length 0.50 mm; height 0.28 mm; width (left valve) 0.13 mm.

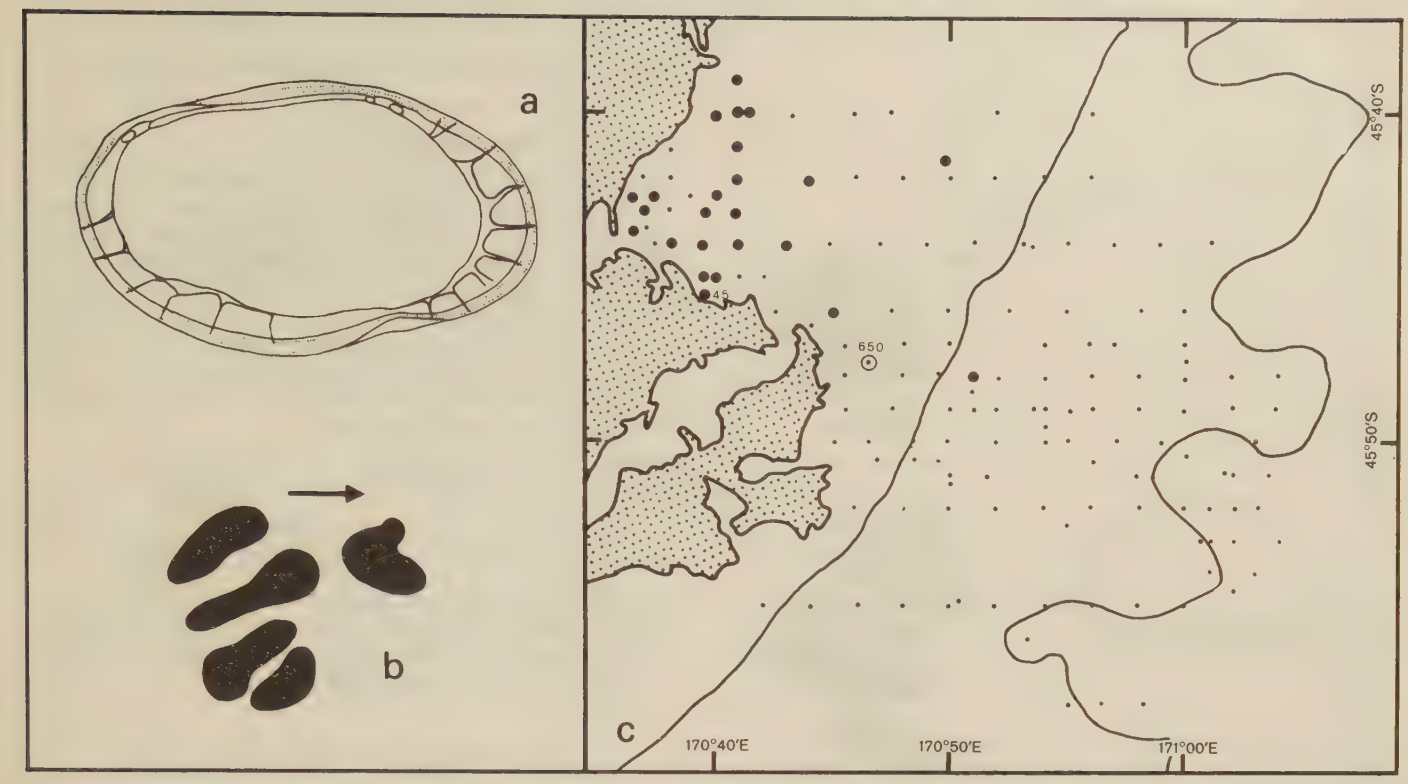


FIG. 52. *Loxoconcha* cf. *L. punctata* Thomson (N.Z. Geological Survey Cat. No. OP 1073): a, internal view of left valve, x 100; b, muscle scars, x 200; c, geographic distribution.

DISTRIBUTION: Occurs rarely throughout the study area, extremely rare on the inner shelf (0–50 m). Biocoenosis depth range: four living specimens located in one sample only: Mu 69-58, 108 m. Thanatocoenosis depth range: 80–140 m. Substrate: muddy sandy gravel, sandy gravel (biocoenosis?).

Sclerochilus sp.b (Fig. 53c, d)

DIMENSIONS OF FIGURED SPECIMEN: Length 0.38 mm; height 0.20 mm; width (right valve) 0.08 mm.

DISTRIBUTION: Occurs rarely throughout the study area, extremely rare on the inner shelf. Biocoenosis depth range: living specimens located in one sample only: Mu 67-120, 99 m. Substrate: gravelly sand (biocoenosis?).

Sclerochilus sp.c (Fig. 53e)

DIMENSIONS OF FIGURED SPECIMEN: Length 0.39 mm; height 0.17 mm; width (right valve) 0.07 mm.

DISTRIBUTION: Rare in mid-shelf and outer shelf samples (50–150 m). Biocoenosis depth range: living specimens located in one sample only: Mu 67-55, 84 m.

Family XESTOLEBERIDIDAE Sars, 1928

Genus XESTOLEBERIS Sars, 1866

TYPE SPECIES: *Cythere aurantia* Baird, 1838

Xestoleberis sp. (Fig. 54)

DESCRIPTION: Carapace tumid, subtriangular. Dorsal margin broadly arched, ventral margin slightly convex. Anterior narrowly rounded, depressed ventrally. Posterior broadly rounded, slightly depressed ventrally. Carapace smooth, normal pores appear externally as surface pitting. Interior: duplicature moderately wide anteriorly, otherwise narrow throughout. Vestibules wide anteriorly and posteroventrally. Line of concrescence sinuous. Marginal pore canals numerous, short, straight to slightly curved; concentrated anteriorly and ventrally. Muscle scars: four simple adductor scars arranged vertically with a V-shaped frontal scar nearby.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.45 mm; height 0.28 mm; width (left valve) 0.14 mm.

DISTRIBUTION: Restricted to the innermost shelf. Biocoenosis depth range: 0–?30 m. Thanatocoenosis depth range: 0–?30 m. Substrate: sand.

REMARKS: Brady (1898), described three new species of *Xestoleberis* from the South Island of New Zealand. *Xestoleberis olivacea* lacks the massive overlap of the mid- and posterodorsal margin of the left valve, while both *X. compressa* (junior synonym of *X. compressa* Sequenza, 1885) and *X. luxata* lack the full posterior and narrow anterior margins of *Xestoleberis* sp. *Xestoleberis tigrina* (Brady, 1866) lacks the well rounded posterior and the dorsal overlap described above.

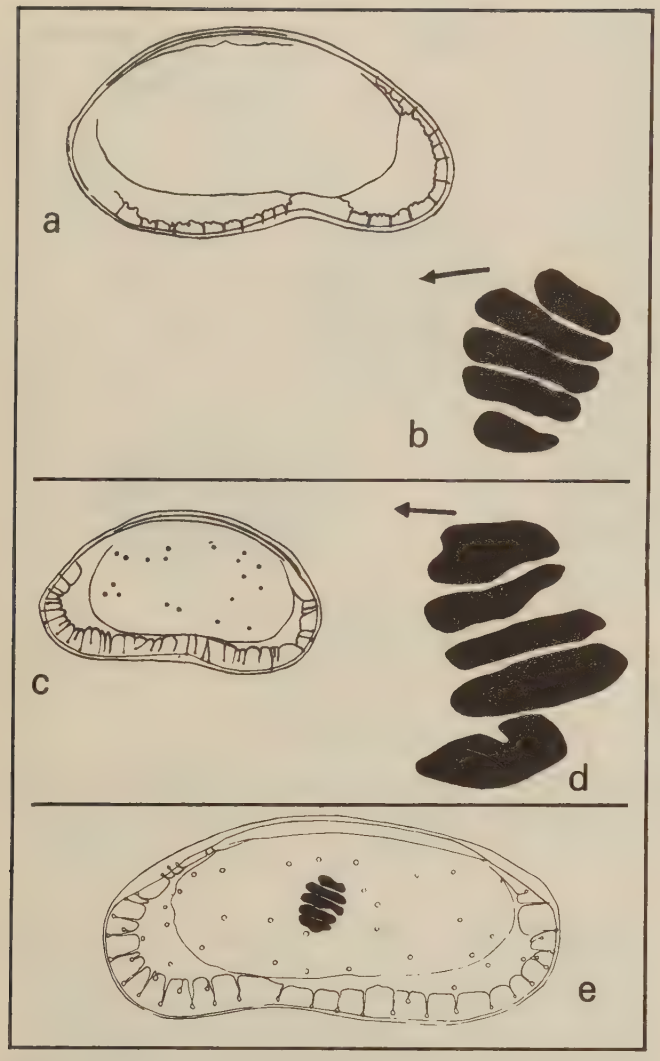


FIG. 53. *Sclerochilus* sp.a. (N.Z. Geological Survey Cat. No. 1069): a, internal view of left valve, x 100; b, muscle scars, x 200. *Sclerochilus* sp.b. (N.Z. Geological Survey Cat. No. OP 1070): c, internal view of right valve, x 100; d, muscle scars, x 200. *Sclerochilus* sp.c. (N.Z. Geological Survey Cat. No. OP 1038): e, internal view of right valve, x 100.

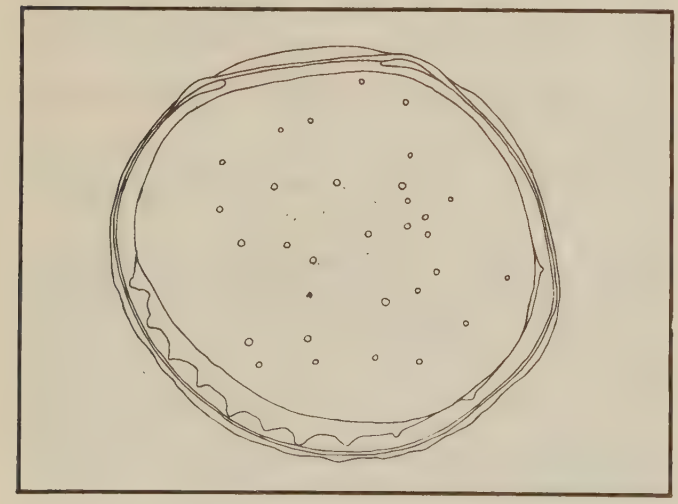


FIG. 56. *Polycope* sp. (N.Z. Geological Survey Cat. No. 1037): internal view of left valve, x 100.

Genus SEMIXESTOLEBERIS Hartmann, 1962

TYPE SPECIES: *Semixestoleberis debueni* Hartmann, 1962

Semixestoleberis taiaroaensis n.sp. (Fig. 55)

DESCRIPTION: Carapace small to medium in size, subtriangular, thick and smooth. Ventral half of carapace strongly inflated. Anterior narrow, depressed ventrally. Posterior tapered, depressed ventrally. Dorsal margin strongly arched, highest mid-dorsally. Ventral margin slightly incurved in the anterior third. Normal pores give surface a faintly pitted appearance. Interior: duplicature extremely wide anteriorly. Selvage subperipheral, strong. Vestibules well developed anteriorly. 21 short, straight, and simple marginal pore canals.

TYPES: N.Z. Geological Survey Cat. No. TO 1034. Holotype and 11 paratypes. Mu 68-79, 5 m.

DIMENSIONS OF HOLOTYPE: Length 0.54 mm; height 0.28 mm; width (left valve) 0.16 mm.

DISTRIBUTION: Occurs throughout the study area, rare in outer shelf and canyon samples (75–500 m). Biocoenosis depth range: 0–30 m. Thanatocoenosis depth range: 0–35 m. Substrate: sand.

Order MYODOCOPIDA Sars, 1866

Suborder CLADOCOPINA Sars, 1866

Family POLYCOPIDAE Sars, 1866

Genus POLYCOPE Sars, 1866

TYPE SPECIES: *Polycope orbicularis* Sars, 1866

Polycope sp. (Fig. 56)

DESCRIPTION: Carapace semicircular, thin, and smooth except for faint rectangular ridge systems apparent under transmitted light. Anterior margin slightly extended just below mid-point. Dorsal view: carapace widest medially, posterior and anterior halves symmetrical. Interior: duplicature narrow throughout, widest posteroventrally. Normal pores numerous, large and evenly distributed.

DIMENSIONS OF FIGURED SPECIMEN: Length 0.37 mm; height 0.33 mm; width (left valve) 0.15 mm.

DISTRIBUTION: Occurs in one sample only: Mu 68-45, 140 m.

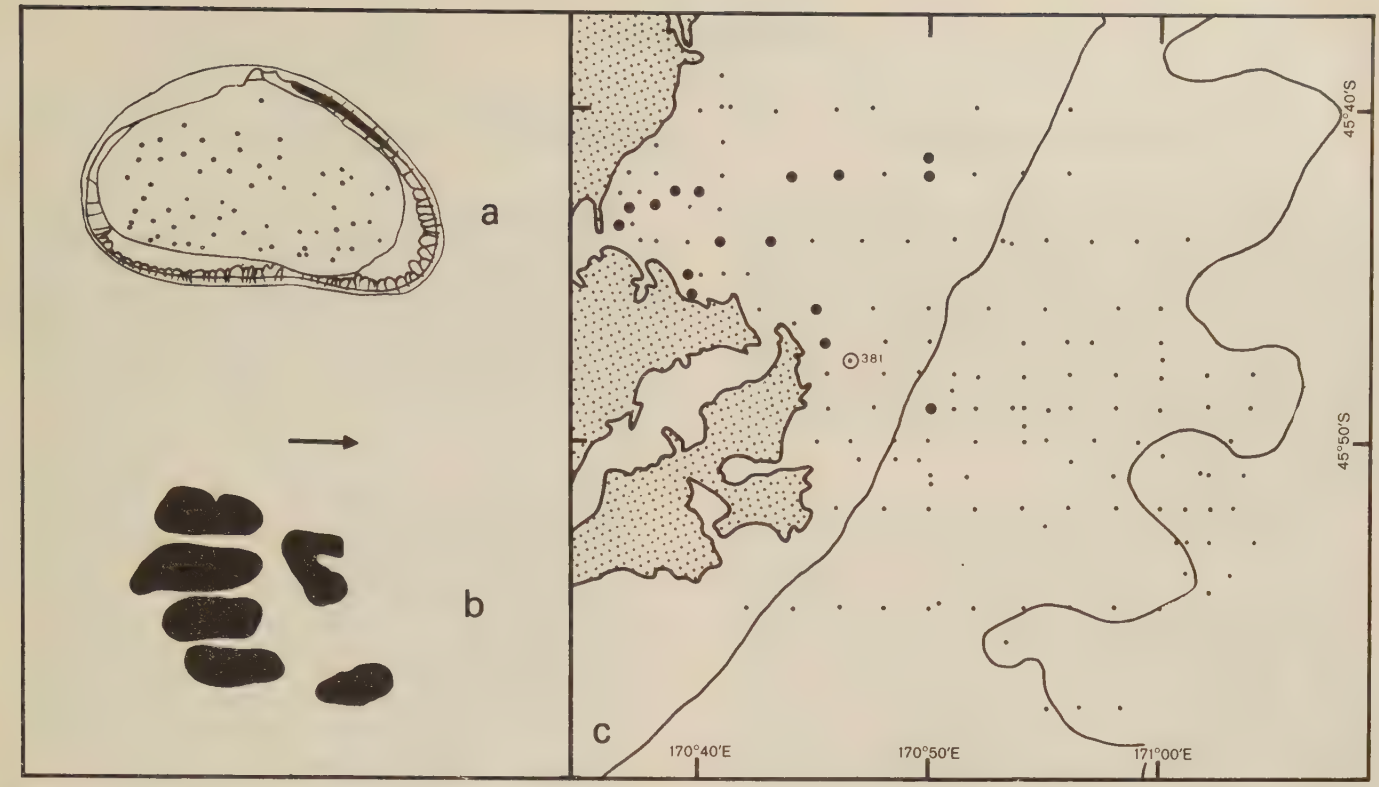


FIG. 54. *Xestoleberis* sp. (N.Z. Geological Survey Cat. No. OP 1072): a, internal view of left valve, x 100; b, muscle scars, x 100; c, geographic distribution.

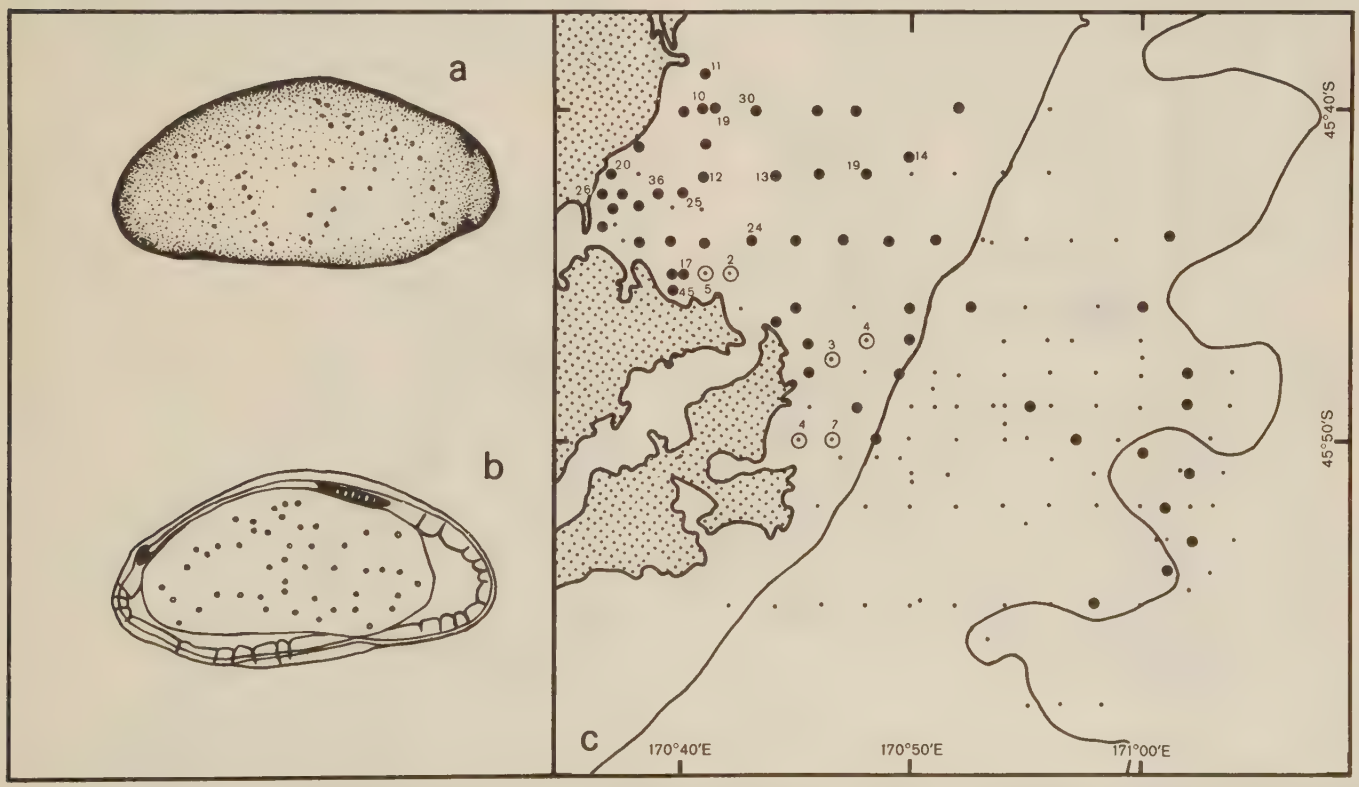


FIG. 55. *Semixestoleberis taiaroaensis* n.sp. Holotype (N.Z. Geological Survey Cat. No. TO 1034): a, external view of left valve, x 75; b, internal view of left valve, x 75; c, geographic distribution.

DISTRIBUTION

Ostracod Assemblages

Five major ostracod assemblages have been recognised in the study area. Boundaries determined are based on the distribution of live specimens only (*see* Collection and Sample Treatment, p. 6–7). Interpretation of bathymetry and sediments indicates the presence of Pleistocene shorelines on the outer shelf, hence some of the dead outer shelf populations could represent the remains of a shallow water assemblage now occurring in deeper water because of post-depositional variations in sea level (*see* Relict Populations, p. 48).

In discussing each assemblage, range of water depth and a number of substrate characteristics are given. It must be realised, however, that since the geographic boundaries of each assemblage overlap considerably, only generalised sediment parameters and water depths are possible. In a study of the sediments of the Otago Shelf, Andrews (1973) also distinguished five benthic assemblages based on foraminifera, bivalves, and Bryozoa. The most encouraging result of these independent studies is the remarkably good correlation between the two sets of assemblages (*cf.* Fig. 57 and Andrews (1973)).

The assemblages proposed in the present study are detailed in Table 1, and the distribution of the various ostracods with depth in Figs 58 and 59.

Sediments and the Living Ostracod Population

Detrital sediments in the Otago Shelf area are predominantly derived from the Otago Schists, with minor amounts derived from Permian and Mesozoic sedimentary rocks. Tertiary volcanics and sediments exposed on the coast are considered of very minor importance in the sedimentation pattern of the study area. Detrital sediment, the bulk of which is supplied by the Clutha River, is distributed by the Southland Current. Andrews (1973) stated :

> Coarse sediments (pebble gravel and medium sand) were supplied and redistributed by the current during the early to middle phase of the post-glacial rise in sea level. Fine sand was supplied as a consequence of a temporary halt in sea level rise that occurred about 8–9 000 years B.P. It was distributed by the Southland Current and is probably being reworked northward by the current today. Very fine sand and coarse silt is presently being distributed, largely by the Southland Current, and to a limited extent by longshore drift.

Andrews (1973) also stated :

> The most significant sediment is the pebble gravel that occurs between 55 and 110 m in the southern and central part of the area. The gravel occurs in three textural classes – gravel, muddy sandy gravel, and sandy gravel. In the south, the gravels consist of very

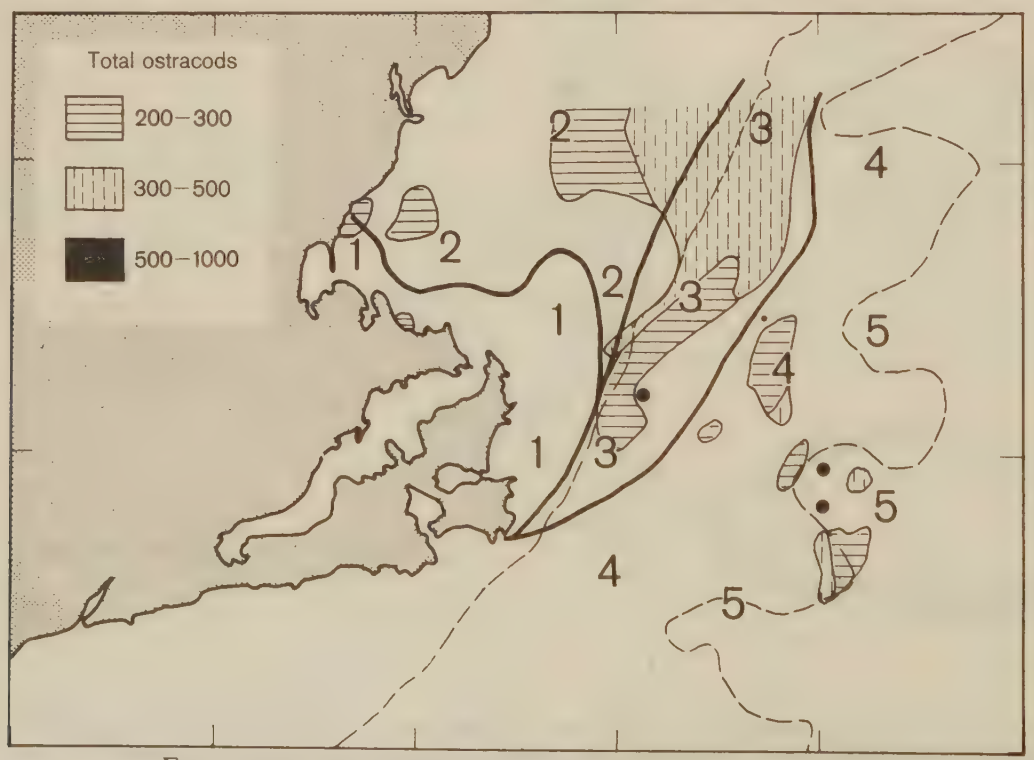


FIG. 57. Ostracod assemblages; the numbers refer to the zones in Table 1. Total ostracod population distribution is also shown.

TABLE 1. Ostracod assemblage zones.

	ASSEMBLAGE 1	ASSEMBLAGE 2	ASSEMBLAGE 3	ASSEMBLAGE 4	ASSEMBLAGE 5
Depth range	0–35m	0–46 m	46–95 m	95–155m	150–750 m
Dominant sediment class	sand	muddy sand	none: varies from gravelly muddy sand to sandy gravel	gravelly sand, sandy gravel	none: varies from muddy sand to sandy gravel
Mean size	2·0–3·0 Ø (0·25–0·125mm)	3·0–4·0 Ø (0·125–0·062mm)	2·0–3·0 Ø (0·25 – 0·125mm)	−2·0–2·0 Ø (4·00–0·25mm)	
Percentage gravel	0%	0%	25–60%	0–75%	0·50%
Percentage organic detritus	0–2%	0–20%	40–60%; minor occurences 60–100%	40–80%; minor occurrences 100%	20–60%
Sorting	well and very well sorted	moderately well – well sorted	poorly – moderately sorted	Extremely poorly–poorly sorted	Extremely poorly–poorly sorted
Characteristic species	(a) ***Semixestoleberis taiaroaensis*** n.sp. ***Pontocythere hedleyi*** (Chapman) ***Hemicythere munida*** n.sp. ***Ambostracon*** cf. ***pumila*** (Brady) ***Waiparacythereis joanae*** Swanson ***Loxoconcha punctata*** Thomson ***Xestoleberis*** sp.		*Cytherella hemipuncta* Swanson		

(b) *Loxocythere crassa* Hornibrook; *Copytus novaezealandiae* Brady; *Callistocythere neoplana* n.sp.

(c) *Munseyella brevis* n.sp.; *Cytherella* sp.

(d) *Kotoracythere formosa* n.sp.

(e) *Munseyella tumida* n.sp.

(f) *Bairdoppilata* sp.; *Sclerochilus* sp.b

(g) *Macrocypris* sp.; *Argilloecia* sp.

(a) The majority of species comprising this assemblage are forms of medium size (0.50–0.75 mm) with thick carapaces. *Hemicythere munida* and *Ambostracon* cf. *pumila* display moderately heavy ornamentation, the remaining five have faintly ornamented or smooth carapaces.

(b) All species small to medium in size. Both *Loxocythere crassa* and *Callistocythere neoplana* have extremely thick carapaces. *L. crassa* is the only heavily ornamented form in this group.

(c) Both *Cytherella hemipuncta* and *Munseyella brevis* have extremely thick shells. The largest populations of *Munseyella brevis* occurred in coarse sands and gravel. *Cytherella* sp. has a large smooth shell of medium thickness. Largest populations occurred in muddy sands, but the species was also common in gravelly sands.

(d) *Kotoracythere formosa*, a thick, smooth shelled form of medium size which occurs commonly in muddy sands, gravelly muddy sands, and muddy sandy gravel.

(e) A species of medium size with a thin, moderately heavily reticulate carapace. Occurs commonly in muddy sandy gravel and rarely in gravelly sand.

(f) Both species are smooth shelled : *Sclerochilus* sp.b has an extremely thin, medium sized carapace and occurs rarely in gravelly sand; *Bairdoppilata* sp. occurs commonly in sandy gravel and rarely in gravelly sand.

(g) *Argilloecia* sp and *Macrocypris* sp. display large, smooth carapaces of medium thickness. Occur only rarely.

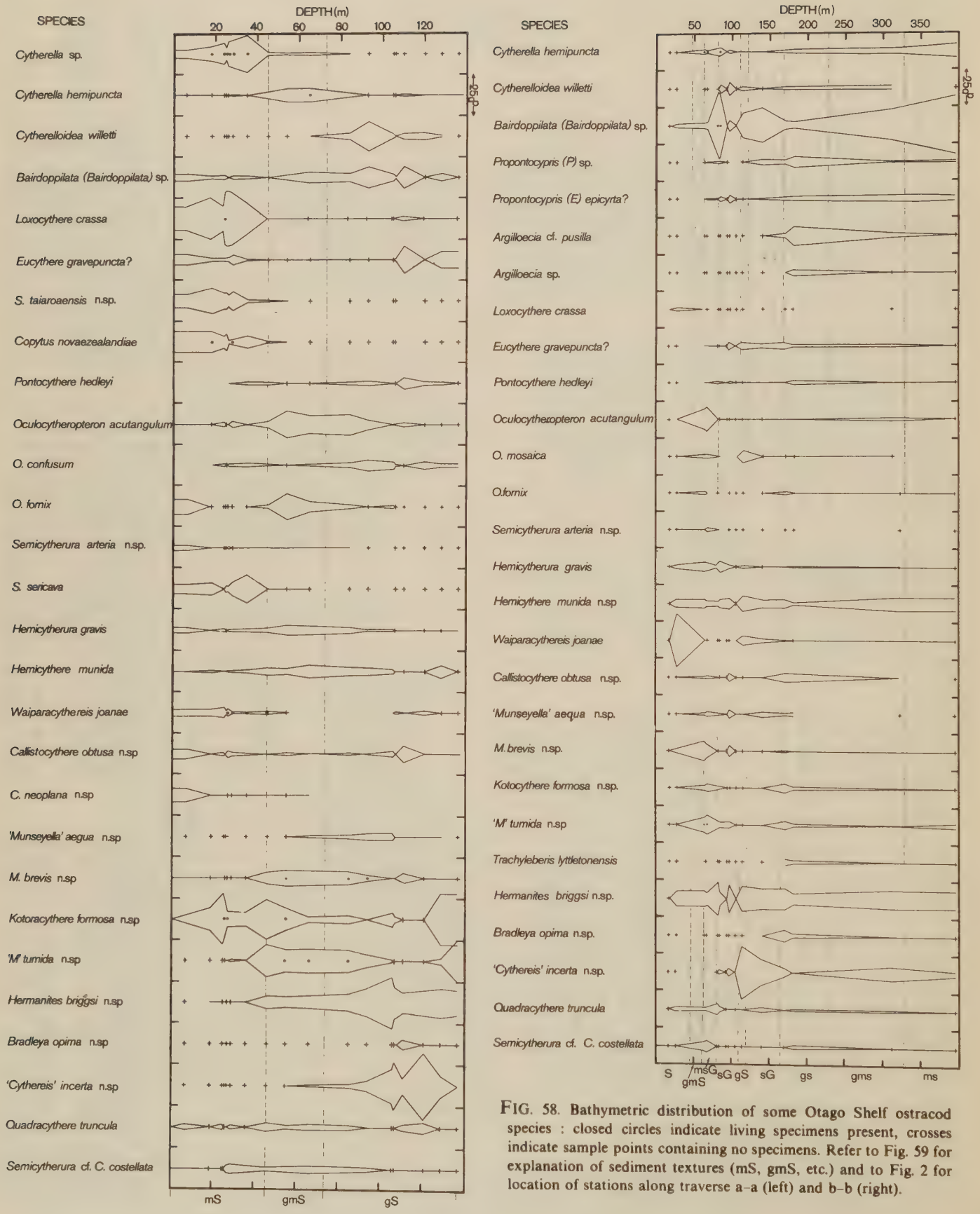


FIG. 58. Bathymetric distribution of some Otago Shelf ostracod species : closed circles indicate living specimens present, crosses indicate sample points containing no specimens. Refer to Fig. 59 for explanation of sediment textures (mS, gmS, etc.) and to Fig. 2 for location of stations along traverse a–a (left) and b–b (right).

coarse and medium sandy fine and very fine pebble gravel ... The pebbles are smooth where not covered with epizoa. Bryozoa and serpulid worm tubes are the dominant epizoa, and completely cover the coarsest pebbles. ... As the gravels are traced northwards, the percentage of detrital pebbles decreases and the percentage of organic debris rises proportionately.

The sediment distribution for the area studied is shown in Figs 60 and 61. The bulk of the Holocene sediment accumulation has occurred on the inner shelf, with minor amounts on the middle and outer shelf. These sediments reflect rather strongly the increasing effectiveness of waves as a winnowing agent as they move shoreward. Inshore sands grade markedly into muddy sands offshore. The areas adjoining and including the upper slopes of the canyons are covered with gravelly sand with small patches of sandy gravel and muddy sandy gravel composed largely of organic debris. Gravelly muddy sand covers the middle and lower slopes of the canyon; dredgings, however, suggest such a layer may in fact be a discontinuous veneer over Tertiary rock.

Ecological studies of marine ostracods (Benson 1959) indicated that substrate played a major role in determining ostracod distribution. Following later, more detailed research, other authors recognised the influence of the substrate on ostracod distribution. Thus Puri *et al.* (1964) noted the association of coarsely ornamented, smooth, or alate forms with fine sediment bottoms.

For the majority of the species living in the Otago Shelf area the influence of the substrate (sediments) on their distribution is not as obvious. Many species display a wide tolerance for variations in sediment texture, grain size, and sorting. It has become apparent, however, that individual species appear to be associated with particular sediment types even though their maximum geographic distribution may encompass areas in which sediments of differing characteristics are present (this assumes that such an association would be indicated by variations in the densities of populations). Kornicker and Wise (1960) suggest, however, that any similarities between the distribution of a species and one environmental factor may be coincidental or may be due to some other environmental factor not measured.

The association of large, heavy shelled and/or highly ornamented forms with coarse sediments probably indicates a genuine relationship. On the Otago Shelf, species such as *Cytherella hemipuncta, Cytherella elongata* and *Bairdoppilata* sp. occur in gravelly muddy sands, muddy sandy gravels, and sandy gravels. The distribution patterns of sediments reflect the influence of the strong Southland Current; the presence of these species in these coarse-grained sediments may reflect their ability to tolerate a mobile sedimentary environment or to withstand damage inflicted through direct transport along the sea floor. This concept is reinforced by the presence of such thin-shelled species as *Munseyella aequa* n.sp., *Sclerochilus* sp. a, and *Sclerochilus* sp. b, in gravelly sands and sandy gravels in zones outside that of the maximum influence of the Southland Current.

Ostracod species in finer sediments fall into two broad groupings. The first includes modestly ornamented or smooth, extremely thick-shelled forms, which occur in muddy sand and sand only: *Loxocythere crassa, Waiparacytheris joanae,* and *Callistocythere neoplana* n.sp. The second group, living in muddy sand, includes large, smooth-shelled species such as *Cytherella* sp., *Macrocypris* sp. and *Argilloecia* sp., and the smaller thick-shelled species *Munseyella brevis* n.sp. and *Kotoracythere formosa* n.sp. Members of this latter group were, however, found to occur in a wide variety of sediments.

Puri (1966) concluded from a study on the west coast of Florida that in clastic sediments clean sands support fewer numbers of species and that the greatest number occur in varying mixtures of sand and mud. In the Otago Shelf area, samples displaying the greatest diversity of species with living specimens were concentrated in coarse sediments (sand - sandy gravel). Of the five samples containing living individuals of more than four species, three (one of which had eight species) occurred in the near-shore, clean sand zone, one occurred in gravelly sand, and one in gravelly muddy sand. Samples containing living individuals of only one species were concentrated in muddy sands. If, however, the total population is included, a completely reversed pattern is evident. Samples with low species diversity (less than ten species) occur predominantly in coarse sediments. Of 16 samples with fewer than 10 species, 7 samples were from sand, 4 from gravelly sand, 4 from sandy gravel, and one from gravelly muddy sand.

Dead Ostracod Populations in the Otago Shelf Area

Biocoenosis or Thanatocoenosis?

From the Otago Shelf study it has become apparent that it is essential to distinguish between living and dead populations if any contribution to the knowledge of the geographic distribution of individual species is to be made. For this study the living population (biocoenosis) is based on the paleoecological concept of the term, which includes the living forms and the dead populations directly associated with them. The thanatocoenosis is represented by transported accumulations and relict populations.

Throughout this section the term 'concentration' is used simply to imply large accumulations of specimens of one particular species. These 'concentrations' should not be considered separate entities defined by some easily determined geographic boundary. Considerable merging and overlapping occurs, the reasons for which will become apparent throughout this section.

Dead 'concentrations' directly associated with living species (biocoenosis)

Unless affected by transport after death it is expected that large accumulations of valves will occur in the area in which a particular species is living. For the majority of species on the Otago Shelf this has proved to be the case. The 'concentration' is generally larger in size (representing many generations of accumulation) and covers a

slightly greater geographic area than its living counterpart. Examples of this type of species distribution occur throughout the study area as is indicated in Table 2. Very little, if any, post-mortem modification of these dead concentrations has occurred and for this reason they are considered to represent a biocoenosis.

Dead 'concentrations' associated with, but geographically displaced from, the living species (thanatocoenosis)

Curtis (1960) stated:

> Currents affect the distribution of the physical-chemical characteristics that effect living organisms and sedimentary particles. Currents also tend to distribute both living and dead organisms as mechanical, detrital particles as a part of the sediment.

Andrews (1973) suggested three possible agents for sediment distribution in the inner shelf and Blueskin Bay portions of the study area. The observed distribution of the five detrital modes (gravel, medium-fine sand, fine sand, very fine sand and coarse silt), is consistent with dispersal by the Southland Current in mid-shelf and outer shelf positions, and by a combination of eddy currents and longshore drift (induced by refraction of southerly swell) over the inner shelf (*see* p.45).

North of the Otago Peninsula, in the absence of strong southerly swell, the prevailing north-east winds are often responsible for the seas running in Blueskin Bay. Sediment distribution indicates a shoreward transport path from east or north-east in Blueskin Bay. The north-east seas may be partly or largely responsible for this.

Of the transport of sediments Andrews (1973) writes:

> Wave conditions must influence the nature and direction of sediment transport over the inner shelf ... In the Otago Peninsula area the gradation seaward from nearshore sand to muddy sand, to muddy sandy gravel and gravelly muddy sand (mid shelf) ... is consistent with wave controlled sediment winnowing related to present day sea level ...

The effectiveness of these transporting agents in the dispersal of ostracod valves is well illustrated by Assemblage 1 species. Here, large discrepancies between biocoenosis and thanatocoenosis exist. In most cases the living forms are restricted to the shallow near-coastal waters of the Otago Peninsula (*Waiparacythereis joanae*, Fig. 33; *Semixestoleberis taiaroaensis* n.sp., Fig. 55; *Loxoconcha punctata*, Fig. 52). Dead specimens, however, are distributed over much of Blueskin Bay and the innermost part of the shelf. The dispersal of these dead forms probably involves two phases of transport.

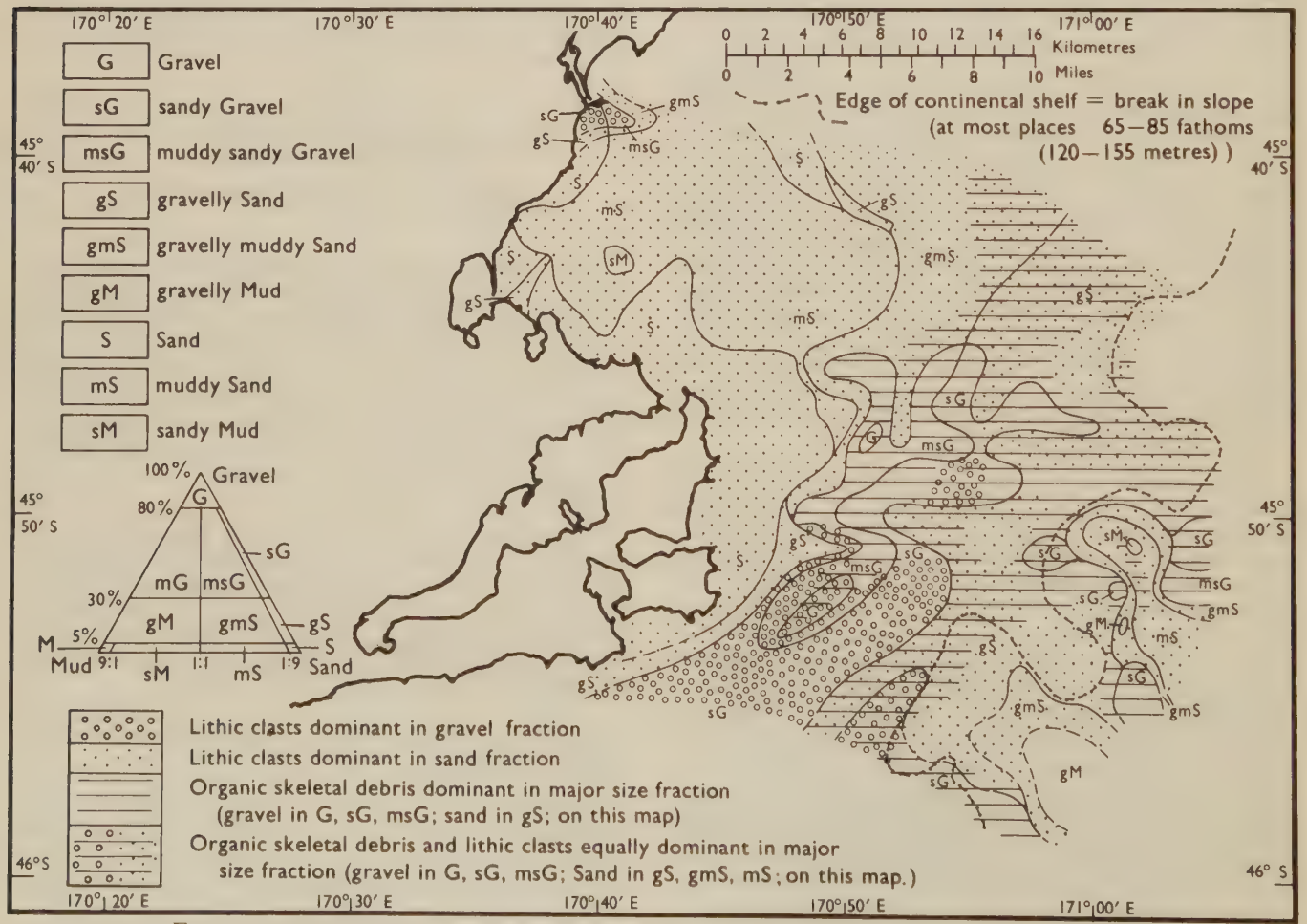


FIG. 59. Bottom sediment distribution showing both texture and gross composition (after Andrews, 1973).

Back eddies from the Southland Current remove dead specimens from the live populations and transport them as detritus to a more northerly site, the inferred path of transport paralleling the sand zone (*see* Fig. 59) around the northern coast of the Otago Peninsula. In the southern half of Blueskin Bay there are large concentrations of dead shell material (particularly of *Waiparacythereis joanae* and *Semixestoleberis taiaroaensis* n.sp.) near shore. This observation, and the sediment distribution, indicate that within this area the eddy currents lose velocity through moving into shallow waters and hence their ability to transport detrital particles. The second phase of shell dispersal is caused by wave action which distributes the material eastward and north-eastwards over the entire sea floor of Blueskin Bay and parts of the inner shelf. The decrease in population density eastwards simply reflects the decreasing effectiveness of wave action to move dead shells in progressively deeper water. Reworking of this 'concentration' by the north-east seas presumably involves only a redistribution within Blueskin Bay and the inner shelf.

Some of the species (*Cytherella hemipuncta*, Fig. 4; *Munseyella brevis* n.sp., Fig. 22; '*Munseyella*' *tumida* n.sp., Fig. 24) living on the mid-shelf and outer shelf were also located on the inner shelf and in Blueskin Bay, and would appear to have been transported by both Southland Current eddies and north-easterly waves. The modifying effect of the Southland Current on living mid-shelf populations is difficult to evaluate.

It seems likely that these populations are relatively stable, since at present only fine sand, very fine sand, and coarse silt is being reworked by the current (these are sediments much finer than the carapace size of the species under discussion). Such a conclusion must be tentative, however, for although there has been much speculation, little factual information has been published on the response of ostracod shells to transporting agencies.

TABLE 2. Depth distribution of living and associated dead specimens

Species	Fig.	Depth (m)	
		live	dead
Cytherella sp.	3	20–65	20–40
Cytherella hemipuncta	4	55–65	?50–85
Loxocythere crassa	21	20–?30	10–40
'*Munseyella*' *tumida*	24	50–85	40–59

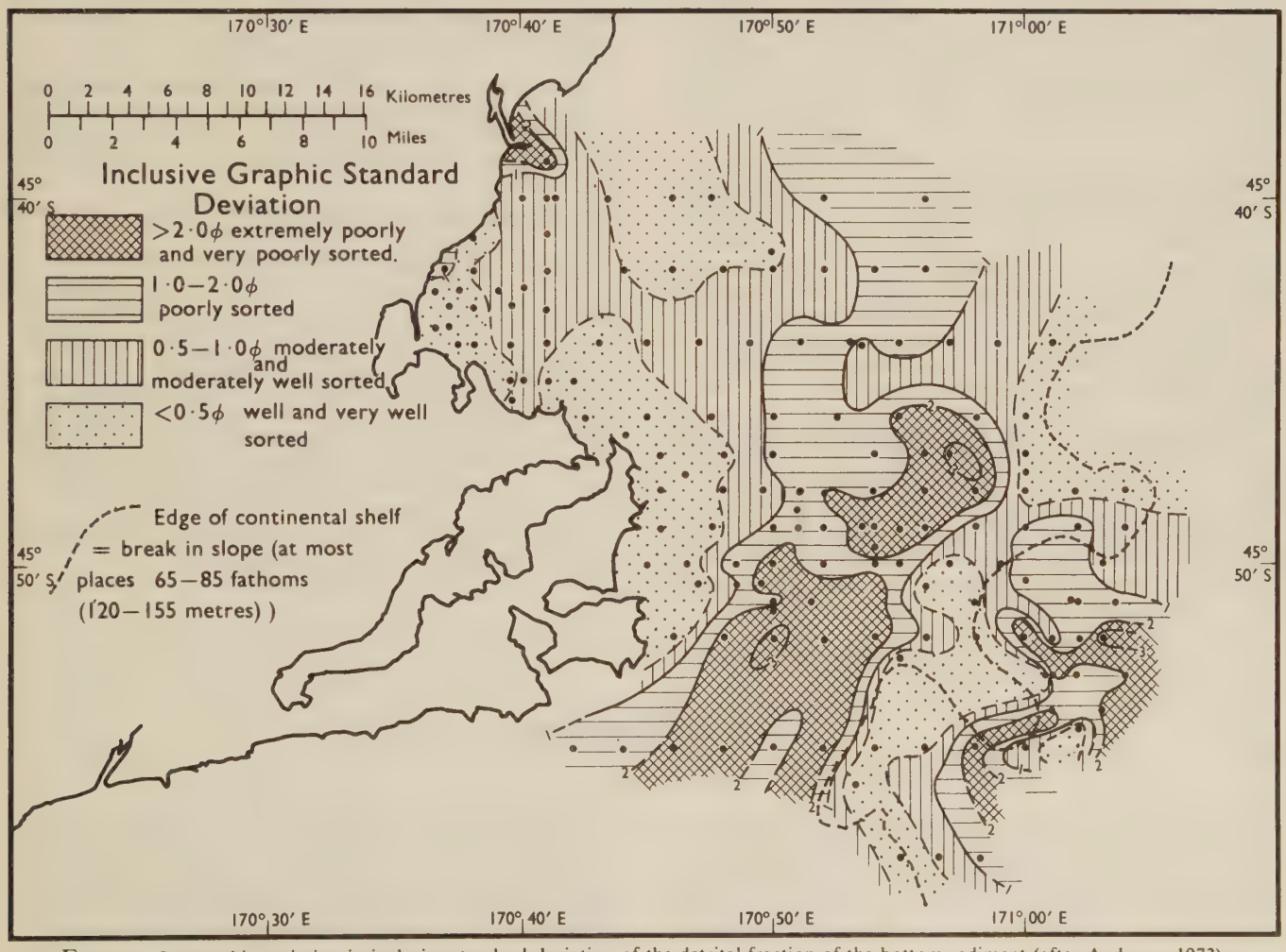

170°30′ E
170°40′ E
170°50′ E
171°00′ E
0 2 4 6 8 10 12 14 16 Kilometres
0 2 4 6 8 10 Miles
45° 40′ S
45° 50′ S
Inclusive Graphic Standard Deviation
>2·0ϕ extremely poorly and very poorly sorted.
1·0—2·0ϕ poorly sorted
0·5—1·0ϕ moderately and moderately well sorted
<0·5ϕ well and very well sorted
Edge of continental shelf = break in slope (at most places 65—85 fathoms (120—155 metres))

FIG. 60. Geographic variation in inclusive standard deviation of the detrital fraction of the bottom sediment (after Andrews, 1973).

Relict Populations

Geological and sedimentological evidence suggest the likely occurrence of relict populations. Bathymetry indicates drowned shorelines at 56–59 m, 84–104 m, and less clearly at 108–133 m. Andrews (1973) has suggested that, in the Otago middle and outer Shelf area where the percentage of organic skeletal debris is greater than 20–30%, the sediments may be regarded as largely relict, having been deposited during lower sea level.

Remains of large invertebrates suggest that "wherever they occur, high concentrations of organic skeletal debris in the middle and outer shelf positions probably represent condensed depositional sequences that reflect a reduction in the amount of sediment reaching the distal regions of the shelf, following the rapid post-glacial rise in sea level." (Cullen ,1970, p. 15). The distribution of most Otago mid-shelf and outer shelf populations is consistent with this concept. Large concentrations of deeper water forms (*Hermanites briggsi* n.sp., Fig. 3l; *Oculocytheropteron acutangulum*, Fig. 44; *Oculocytheropteron fornix*, Fig. 46; *Hemicytherura gravis*, Fig. 50; '*Cythereis*' *incerta* n.sp., Fig. 37) occur in mid-shelf and outer shelf sediments. The possibility of some populations being moved en masse from a more southern location seems unlikely. The lack of complete carapaces in the populations of these deeper water forms could be used as evidence for transport (the inference being that the greater the distance of transport the fewer the carapaces which remain intact). I favour the concept of Oertli (1970):

> Those who have observed the development of ostracods in an aquarium know that almost immediately after death of an individual (few hours at maximum) the carapace opens and valves separate because of the intense bacterial activity. It is possible to see that in an environment of slow sedimentation this same phenomenon will take place. The bottom is relatively consolidated and only a small portion of the dead individuals sink deep enough into the sediment to prevent opening of the valves.

Almost complete sequences illustrating gradual deterioration of the ostracod valves occur within each population. Opaque, yellow-brown stained (often matrix filled) valves represent forms of earlier generations, transparent carapaces and valves belong to the more recent generations. Thin shelled and/or finely ornamented species (*Anchistrocheles arcaforma* n.sp., Fig. 7; *Bythoceratina fragilis*, Fig. 15; *Bythoceratina tuberculata*, Fig. 16; and *Pseudocythere* (*Plenocythere*) *fragilis* n.sp., Fig. 19) in excellent preservation on the mid- and outer shelf indicate the relative stability of these populations. Occurrences of relict population species (*Hermanites briggsi* n.sp., Fig. 3l; *Quadracythere truncula*, Fig. 28; *Hemicytherura gravis*, Fig. 50) in shallow waters (inner shelf and Blueskin Bay) demonstrate the effectiveness of the Southland Current eddies and north-easterly waves as dispersing agents (*see* p. 42). To explain such occurrences it is suggested that only the western margins of the populations are being reworked to provide small numbers of valves.

Distribution of some relict forms suggests that some mixing of depth-controlled species has occurred. The presence of dead 'concentrations' of shallow water species (*Semixestoleberis taiaroaensis* n.sp., Fig. 55; *Loxocythere crassa*, Fig. 2l; *Waiparacythereis joanae*, Fig. 33; *Pontocythere hedleyi*, Fig. 4l) at extreme depths on the outer shelf, often some considerable distance from their living counterparts, excludes the possibility that these concentrations have been transported. The presence of the thin-shelled shallow-water species *Anchistrocheles arcaforma* n.sp. and *A.* sp. reinforces this. Maddocks (1969), in her description of several species of *Anchistrocheles*, concluded:

> All these species characteristically inhabit the microfloral jungle of encrusting algae, marine grasses, corals and coral fragment accumulations in coral seep and other very shallow water habitats.

Dead 'concentrations' occurring in canyons

This group excludes the first type discussed (p. 45), and is a 'concentration' associated with the living species *Argilloceia* sp. (Fig. 12) and *Macrocypris* sp. (Fig. 9).

It seems likely that specimens contributing to this type of population have been displaced from the eastern margins of mid-shelf and outer shelf populations. Dispersal of sediments in and around the canyon heads is not well understood, but work by van der Linden (1969, p.102) on the offshore sediments of north-west Nelson, New Zealand, suggests that the sudden break in continental slope may give rise to considerable turbulence.

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APPENDIX. Distribution of Ostracoda in the bottom sediments of the Otago Shelf area. * = living specimens present. On line 28, for *Ambostracon* cf. *pumilum* read *Ambostracon* cf. *pumila.*

SPECIES	SAMPLE	69-74	68-79	68-80	69-73	68-74	69-15	69-12	68-53	68-77	69-1	68-15	68-57	68-63	69-54	69-72	69-13	69-14	68-40	68-61	68-47	68-62	68-70	68-16	69-43	69-75	69-76	69-33	69-53	68-42	69-2	69-8	69-9	69-10	69-11	69-42	68-18	68-41	68-72	69-14a	69-48	69-3	67-125	69-15a	69-16a	69-29	69-31	69-32	66-13	66-49	69-28	69-30
	DEPTH (metres)	3	5	6	6	7	10	11	11	11	12	12	12	12	13	13	14	14	15	15	17	17	18	19	19	19	19	22	22	24	24	24	24	24	24	24	25	25	25	26	26	27	28	28	28	28	28	28	30	30	31	31
Cytherella sp.			1	2	13	2						5					1	1				1	2* 22	5	1																					1				6*	
C. hemipuncta											1						1									2															3		1					2		
Cytherelloidea willetti												2											2	1																						1				
Bairdoppilata (B.) sp.		2	9	3	11	1						1	1						4	1		2	1	1	5	3			1	3		3		1		1	1	3	3	1	1			1	3		3	7	3		■	
Macrocypris sp.																																																			
Propontocypris (P.) sp.																																																			
P. (Ekpontocypris) epicyrta ?																																																			
Argilloecia cf. *pusilla*																																																			
Argilloecia sp.																																																			
Bythocythere bulbus n.sp.																																					1											3		1		
Bythoceratina decepta							1																															2									2		2		
B. edwardsoni																																																			
B. fragilis																																																			
B.maoria																																																			
B. tuberculata																																																			
Miracythere novaspecta																																																			
Pseudocythere (P.) caudata																																																			
P. (Plenocythere) fragilis n.sp.																																															2	1	1		1	
Loxocythere crassa		8	175	35	38	38	1	1		15	3	19	9		1	20	9	4	6	27		11	9	19	3	10	10		1*	1*	3	20	44	64	26		34*	1	81*	69	2	43		29	43	7	24	1	9	8	10	22
Callistocythere obtusa n.sp.		1	5	8	16	1				1		3			1				3	4		1	1	3		4					6	2				6		1	8				3	3	2	6	17	8		1	1
C. neoplana n.sp.		1	2*	12*	21*	2	1			2	1	1			1	1*			1*	5		2	2	1					1*		1		2		3			1		1			1	3*	5*	2			1
'Munseyella' aequa n.sp.		1	3	3		1			1				1						1	1				1										1		5			2			1			1	2	3		1	
M. brevis n.sp.					2								1			2				1		2		1	1	3				2	1				7	1			1					1	7	10		2	7
Kotoracythere formosa n.s.p		3	8	11	24	5	1			4	2	9	7			6	5	1	5	12		4	30	14		21*				1	8	39	1	48	10	7		3	50*	17*		4			14	10*	3	5	1	35*	14	7
Munseyella modesta n.s.p.																																																				
'M.' tumida n.sp.		2	3	1																		2				1								1		4			1					2	1	3		23		31	4
Hemicythere munida n.sp.			23*	7		3			1		1	4	1				1		5	14	5	10	3	4	2			3		1	1			2	3	8	2	2	2	2		2	2	1	8	15	14		5	1
Ambostracon cf. *pumilum*			5	2	10	1				3										1			6		1*									2				1													
Waiparacythereis ipanae		8	23	12	10	6		2	4*	2	4		29*		1	2			18	20		11	8		14	9	2		6*	11*	14	7	3	4	11	10	3	17	6	8	14	1		3	2	6*	24	42	28	10*	13	16
Jacobella papanuiensis n.sp.																																																1			1
Quadracythere truncula		2	12	4	8	4		2			1	1				4			9	11		3			4	5	1			5	4	4	3	1			3	2	6		1	1	1			2		2	16	5		2
Hermanites briggsi n. sp.			1																	3			2		2					1					5	1	1	3		4			1		1		11		8	1
Bradleya opima n.sp.																																																			
Trachyleberis lytteltonensis																																																			
T. thomsoni																																																			
Pontocythereis decora n.sp.																																																			
'Cythereis incerta n.sp.								1									1			1															1			1		1											
'C.' planalta																																																			
Hermanites andrewsi n.sp.																																																			
Copytus novaezelandiae		1	10	9*	33	1	1	1*		2	10*	10*					2	2	2	10		13	30*	10*	3*	8*			3*		6	8	6	7	14		6	7*	25	4	1	9		2	4*	1	6	3*	12*	1*	5*	4
Pontocythere hedleyi		2	1	1						2					1*				3	2		2								3*								20*		1			2	1	3	8	2				1
Eucythere (R.) gravepuncta ?		2	2	4	17		2			2		14				3	1	4	1	10		3	5	14		3	2				4	2	1	4	3		1		6	4		2		6	6	3	1	2	13			
Semixestoleberis taiaroaensis n. sp.		8	26	9	20	2	2	2		5	5*	3	2*		4*	1	4		7	45		17	36	3	4	9	3		7*	3*	1	12	8	10	11			7	1	13	9	9		7	19	1	24	28	14	4*	4	6
Krithe sp.																																																			
Parakrithe sp.																																																			
Oculocytheropteron confusum		1	10	1		1	1	1		5	2					1			7	5		6	1			10				1	2	1			2	2		2				2		18	5	1		6	1
O. fornix		2			2											2										2																									
O. mosaica																				1																																
Cytheropteron (C.) wellmani																																																			
Semicytherura cf. *S. costellata*				3	7					1										2					1	1					1			1	3		14			8			5	2	2		5	8		4	4
S. sencava		1		3	2					1		3								4		18	16	14	1	7	5				1	1	4	15	21		24		11	6	1	6		7	11	4	4	2	17		4	10
Hemicytherura (H.) aucklandica																																																			
Semicytherura artena n.sp.				2	7		1			1		1					1	1		2					1								2	2					1							3		1	
Hemicytherura (H.) gravis		1		2	8	1	1			2		1						1		2			1	3	2	7			1		2	2		1					2	1		2	2	2		11	14		4	1
H. (Kangarina) radiata																																																			
Loxoconcha cf. *punctata*		3	13	8		3		3		1		4				1			2	45		7		4		5	2			650*	2	1	2	1	1			1	1		1				6	2	3				
Sclerochilus sp.a																				1						1					1		1		1						2			1			3			1
Sclerochilus sp.b																																																1	2			
Sclerochilus sp.c																																																			
Xestoleberis sp.		1	4	2												1	1			4			1							3* 81	1						1	1	2					2		2	2	2			
Cytheralison lava																																																			
Anchistrocheles sp.																																																			
A. arcaiforma n.sp.																																															2	1	1		1	

SPECIES	SAMPLE	68-19	69-17	67 124	69-60	69-70	66-38	69-18	69-27	68-35	68-20	68-49	69-69	66-36	69-19	69-68	66-25	69-26	69-59	68-21	69-34	68-36	67-140	67-123	69-20	67-79	67-135a	67-139	67-141	69-25	67-126	67-127	68-32	67-136	68-67	67-119	67-122	69-52	67-137	66-39	67-53	69-24	68-38	67-128	67-129	67-134	69-23	68-23	67-120	68-33	69-35	69-41
	DEPTH (metres)	32	35	37	41	41	44	45	46	46	47	50	50	52	54	54	56	56	57	58	61	62	63	65	65	67	67	67	67	69	75	75	75	76	76	78	78	80	82	84	84	84	92	93	93	93	93	96	99	100	101	101
Cytherella sp.		4	25					4			13		1		5		8	3		7	4	1	4		6	29		3	5	1	1		1						1		2	1											
C. hemipuncta								7			58		1	4	34		55	7		44	1	8	16		23			5		7			1			2				10	5	3					1					
Cytherelloidea willetti						1			1							1	1			1					1								6			3			4	8	15	19				25	5	5	5	16	
Baird oppilata (B.) sp.		1	2				8	2	2	1	5	1		3	11	14	14	1		30		6	18		18	1		16	10	10	22		23			22		4	47	18	69	18	42			20	19	4	54	3	15	
Macrocypris sp.												1	1		1		1											3												2							1				
Propontocypris (P.) sp.																	3			1			9		3			2	1											1	2	5	1	1				3	2	4		
P. (Ekpontocypris) epicyrta ?														1											1																3	1	3				1		2			
Argilloecia cf. *pusilla*																																																			
Argilloecia sp.															4													1																								
Bythocythere bulbus n.sp.		1					1		1		3	1		6	3		2			2	3		14		3				2	6	1				3				1	9					3		6		2	
Bythoceratina decepta					5	3	2	2				3		3	1		3				6				5					6											9				3				2	
B. edwardsoni											1									3			1							1										1							2			
B. fragilis											2						1			3	1								3											2						2			
B.maoria																																																		
B. tuberculata		1				1			1		2	1		2	4		6			5	5		12	1	8	1		9		5			3			2			1	4	7	3			1	4		5		5	
Miracythere novaspecta																																																		
Pseudocythere (P.) caudata									2														2																												
P. (Plenocythere) fragilis n.sp.			1					1																	2			2		1																			1	
Loxocythere crassa						1	5	2	1			3	1		2	1		1	1		3									2								1		1		1	3									
Callistocythere obtusa n.sp.		5	2					1	4	3	2	4	3	3	7	6	1			4	7	1	10		3			7	2	3	1		4						1		4	9			1	3	7	1	21	
C. neoplana n.sp.								1	1													1			1																									
'Munseyella' aequa n.sp.		6							6	2	2	1		4			1			5	3		8		3			11	4	3	1		1			1				3	9			6	3	7	4	11	
M. brevis n.sp.		13				1	4	13	3	10	11	15	4	58	40	1	9	26		9	43	25	77		26	1		33	13	27	5					8		1	1	1	26	13			5	4	2	1	10	
Kotoracythere formosa n.s.p.		15						3	15	75	45			21	56						42		8	27	11			17		13											11				8						
Munseyella modesta h.s.p.																							2																												
M. turnida n.sp.		13	1				21	37	20	30	44	19		69	54					33	32		59	16	45		1	45	15	43	4		10			5				6	50	4			11	2	13	1	14	
Hemicythere munida n.sp.		6	2				7	8	3	18	5	1		3	14		26	3		47	8	10	34	1	23			13	13	6			9			8		20	3	12	9	19	7		3	7	4	6	4	3	
Ambostracon cf. *pumilum*																																																		
Waiparacythereis joanae		7	1					13	4	6	10				4		1	1		1																													1	
Jacobella papanuiensis n.sp.									1							2			3		7					4					2		1		2		3				2		1		1	
Quadracythere truncula		4	5	6		3	26	10	33	6	11	1	3	7	8	5	4	1		18	8	1	9	5	12			7		4	1		4		1	3		6	7	7	7	10	5		2		1	1	3		4
Hermanites briggsi n sp		1				13	12	15	5	27	35	18	10	20	26	21	30	4		76	12	30	62	18	22	5		30	47	15	4		14			22		75	23	32	16	38	37		20	25	10	32	15	68	
Bradleya opima n.sp.																																																		
Trachyleberis lyttletonensis																												1																							
T. thomsoni																																																		
Pontocythereis decora n.sp.																												1																				2			
'Cythereis incerta n.sp.												1				1	3			6		1			4			2				6		1	1		1		4	3	7	18		3		8	3	11	7	28
'C.' planalta																																																		
Hermanites andrewsi n.sp.																																																		
Copytus novaezelandiae		5	8					2	1		1				2			1		1		1	2										1																		
Pontocythere hedleyi			5	2				1	3	1		1				2				1		2	4					2	8	3		1		2		2		2	6	3			4	1	6		8	
Eucythere (R.) gravepuncta ?			1				1		1						1					1			2					1	2											4			3	5	4	2	18	
Semixestoleberis taiaroaensis n. sp.		9	30				1	2	2	1	2	1		1	1							1																								1				
Krithe sp.												1																																							
Parakrithe sp.								1																																											
Oculocytheropteron confusum		4	2					3	2	3				2			6			20	1		9		5			3	4				3			2			2	9	2	9	9			9		8	5	17	
O. fornix						14		4		2	84		4	24	63	20	20	6		31		4	10		20			2	1	5			1			1			7	1	9									
O. mosaica		3								3	82	10		27			21			30			12	1				8	4			1			4				1		4				2	7	2		
Cytheropteron (C.) wellmani																														1																				
Semicytherura cf. *S. costellata*		25	5				1	4	1	2	1	3	3	13	15	5		8		1	15	8	35	8	13			26	5	10	1					4				11	1			3		5		3	
S. sericava		7	18					2	1																	1				2																			
Hemicytherura (H.) aucklandica																																																		
Semicytherura arteria n.sp.		1	1				1	1		1		2	1	5	2			1			1	1	3	1	2			8		1										1										
Hemicytherura (H.) gravis		4	2					5	2	7	10	2	2	8	24	4	5	7		18	15	16	39	1	16	6		25	8	29			1					2			3	12	8			2		3		6	
H. (Kangarina) radiata																																																		
Loxoconcha cf. *punctata*										2																																								
Sclerochilus sp.a		3					1	1			1			4	6					2			12			1		1	1	2																					
Sclerochilus sp.b							1				2									2		1	9	1				1	2	2								4	2		5					1	1	1		
Sclerochilus sp.c																				1											2									1										
Xestoleberis sp.				2																			1																											
Cytheralison fava																																																		1	
Anchistrocheles sp.															1				2			1																									2			
A. arcaforma n.sp.			1					1																	2			2		2																		1		

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	DEPTH (metres)	103	103	105	105	106	108	110	110	110	114	115	116	116	118	120	123	127	128	140	140	140	140	144	151	151	151	153	163	168	170	178	178	182	182	187	210	234	279	290	321	378	397	430	430	480	500	580	630	660	750	520
Cytherella sp.																			1																2							2		1						1	1			
C. hemipuncta								1		3														3						1			4	4				1			7		1			1	3				
Cytherelloidea willetti		1	6		3	1	8	27	7	5	2			3	1	2	4	1	2			1		3	4	4		4	4	58	1	7			6	4		9	3	8		6	3		5							7
Bairdoppilata (B.) sp.		12	2		5	1	33	90	10	24	15	1		59			5	3	6	48		2	17	19	8		11	32	12	7	50		3	21	10		8	31	94		50	28	23						19		69
Macrocypris sp.									1	1	1			19					2	6				7	3	1	6	3	8	3		7			9	16			6	12		3	1	1		3	7	4	5	11	15	
Propontocypris (P.) sp.					1		4	3	2	3				21			2			2				10	3	4		4	6	3		12			7	6		1		4		12	4	2		7		15	6	18	6	7
P. (Ekpontocypris) epicyrta ?							1									1													3										1							2			1
Argilloecia cf. *pusilla*																																	9	40				8							6	17	6	10	30
Argilloecia sp.			1				8							6											5				5		5			2	9		1		7	1		2		1	10		6	10	8	8	16
Bythocythere bulbus n.sp.					3		1		1					1						1					1				4	3			1	4				5		8			1	4	5	3		4	1
Bythoceratina decepta					3		1		1						2			1	1				1							1			6					5												
B. edwardsoni																														2								2		3							2			1
B. fragilis																																									3										
B.maoria																							1							1														4							
B. tuberculata		1					3		2										1				2					1	1	1			9	3		1		6		5							4		3	
Miracythere novaspecta																																	2																
Pseudocythere (P.) caudata			2		2				1					4						1			4	1	2				9				2	10				4		2			1	6	1	14	4	12	8	4
P. (Plenocythere) fragilis n.sp.																																												1						
Loxocythere crassa			1								4			1	1				1				3		2			2	9	1	4			3	1			2	5		3				3	1		1		3
Callistocythere obtusa n.sp.					4		22	20	12	19		1		25			9			2			6	2	5		1	8	18		15		1	21	14		6	14	17		1	2			25	6	34	26	8	18	1
C. neoplana n.sp.																																												4						
'Munseyella' aequa n.sp.			5		5		2		7					7					1	7			2	2	6			8	3	7			6	6		5		8						8	9	8	3		7	2
M. brevis n.sp.			4				4	11	2	11				3					1				4	3	5		4	7	3	1			4	2		2	6		1	1			5	7	3	4		2	
Kotoracythere formosa n.s.p.					6	5									22				1	1	41										34		23	8			38						6	22		28				
Munseyella modesta n.s.p.																				11																												2			
'M.' tumida n.sp.			8		2		6		3					15	1				5	1			12	7	11			14	1	6			18	4		1			8	2		2	14	16	8	17	7	3	5	1
Hemicythere munida n.sp.		2			3		9	1	4		9	1		13	1		1		10	10			12	3	12		3	11	6	1	15		1	21	4		1	15	30		24	11	5	14	2	8		11	1		
Ambostracon cf. *pumilum*																																																		
Waiparacythereis joanae					1	1		1		1	6	1		2	1	1		1		5			2	3	1		1	6		3	2		1	4		1	2			1	4			4		1				
Jacobella papanuiensis n.sp.						1	2		2			1		6	1	1				7			9	10	3				4	14			8					15		9				19	8	22	3	1	6	22
Quadracythere truncula			5	4					4	1	6	1		3		3	2				6		2					3	1	2	4		3	3	1	1		8		3	4			9		8		2	1	2
Hermanites briggsi n. sp.		30	28		34	15	13	56	20	23	15	9		69	13	10	17	13	24	28		6	7	30	26		24	51	23	40	64		8	49	18	12	14	32	66	3	31	30	7	1		64	8	110	5	6	14	1
Bradleya opima n.sp.										10				3						1					1	3								28	6				11		2				15	1	8	3	10	1	
Trachyleberis lyttletonensis										3															1							15	5				2	1	1					1	11	4	8	4	6
T. thomsoni										2				1																		9	5						1					6	2	2		3
Pontocythereis decora n.sp.				2					1				3					1	1																														
'Cytheres' incerta n.sp.				6		22	23	4	9	15	18	31	24		56	18	20	8	15	18	35		11	31	23	16	33	45	6	53	70		30	21		19	5	36	72		23	39	2		50	7	54	4	2	4	
'C.' planalta																																		9												2	1	3	1	4
Hermanites andrewsi n.sp.																									2				2															2						
Copytus novaezelandiae														25		1	2	1	2	1			19	9	8		21	20	1	8		1	6		3	8	12		2	4				1					
Pontocythere hedleyi					1			5		13																														4				26	7	13	2	4	2	
Eucythere (R.) gravepuncta ?					1	3	2		5	31	4			31	1		7		14	5		1	7	24	10		3	10	11	3	17						5	12	7	2	4	6			14	5	2		1		
Semirestoleberis tairoaensis n. sp.										1	1												1				2	1	1		1			2			1		4					3		1				
Krithe sp.																																															27		1	
Parakrithe sp.																																																2	3	
Oculocytheropteron confusum		1	3		5	1	13		13			1		2	1	2			3	1			2	1	7				3	1	6			7	2		3		11	2	1				14	4	5	3	2		24
O. fornix			8		2					8									1										1		6			5	1				4										1	2
O. mosaica												1							1	7									1	7	16								25					13	3	4	2	4	4	14
Cytheropteron (C.) wellmani														8									1				2	5		4			7			1		2		3				12	1	11	7			16
Semicytherura cf. *S. costellata*			2				7	4	1	1													1	1									5											1	3	3	2	1			
S. sericava															3																		1											2			2	1			
Hemicytherura (H.) aucklandica																																														2			2	1		
Semicytherura artena n.sp.																																															1				
Hemicytherura (H.) gravis			1		2		5	11	3	2	1			1			1						2		3		1	1	2				1	2		4	1	1	2		3				3		1	1	5		7
H. (Kangarina) radiata																																		4																	
Loxoconcha cf. *punctata*																																																			
Sclerochilus sp.a							1							1																			2					2		1						4	2			8
Sclerochilus sp.b							1																					1											1							2	1			
Sclerochilus sp.c																																					2							1		5	1	6	3	
Xestoleberis sp.																																																		
Cytheralison fava				1					1			1		1	1	1		1	1				3	1				2	1	3			3	1				8		2				6	1	2		1	
Anchistrocheles sp.			1											2									1	1				5		3														2	4	4	1	2	4	
A. arcaforma n.sp.																				1																										1						

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